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REPORT

OF THE

Soil Chemist and Bacteriologist

OF THE

New Jersey Agricultural (College) Experiment Station

New Brunswick, N. J.

BY

JACOB G. LIPMAN

AND

AUGUSTINE W. BLAIR

FOR THE YEAR 1913

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REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST.

Report of the Soil Chemist and Bacteriologist.

JACOB G. LIPMAN.
AUGUSTINE W. BLAIR.
HARRY C. MC LEAN.
LOUIS F. MERRILL.

LIME AND ROTATION EXPERIMENTS.

These experiments, which were begun in 1908, were carried out on twenty-eight one-twentieth acre plots designated on the plan of the General Experimental Plots as plots 21 to 48 inclusive. The land is level and fairly uniform, the soil being a gravelly loam underlaid at a depth of eighteen to twenty inches by coarse loamy sand. The land was used for general farming for a number of years but had been much neglected. It had not been heavily manured and lime had not been used for twenty or twenty-five years.

The twenty-eight plots were divided into four sections of seven plots each, and to each section was assigned a different rotation. The rotations for the different sections are as follows:

Year.	*Plots 21 to 27.*	*Plots 28 to 34.*	*Plots 35 to 41.*	*Plots 42 to 48.*
1908, ...	corn (vetch)	corn (vetch)	corn (vetch)	corn (crim. clover)
1909, ...	oats (cow peas)	potatoes (rye)	potatoes (rye)	oats & peas, millet
1910, ...	wheat	rye	tomatoes (rye, vetch & crim. clover)	winter vetch, rape
1911, ...	timothy & clover[1]	timothy & clover[1]	lima beans (rye, vetch & crim. clover)	rye, cow peas
1912, ...	timothy & clover	timothy & clover	cucumbers (rye & vetch)	oats & peas, cow peas

---

[1] On account of the failure of timothy and clover, oats were seeded on these plots the following spring.

The first plot in each section is the check with respect to lime treatment. The second, third and fourth plots in each section received in 1908 one-half, one and two tons respectively of ground non-magnesian limestone per acre, while the fifth, sixth and seventh plots received one-half, one and two tons respectively of magnesian limestone per acre.

Chemical Analysis of the Soil.

In 1909 samples of soil for analysis were collected from certain of these plots. These analyses were made by Mr. R. B. Gage of the New Jersey State Geological Survey. The results are reported in Table I.

Table I—Chemical Analyses of Soils from Experimental Plots.

Plot Number,	*32.*	*36.*	*42.*
	Per Cent.	*Per Cent.*	*Per Cent.*
Insoluble matter,	86.38	88.51	88.53
Soluble silica,	.03	.07	.11
Potash (K_2O),	.20	.14	.15
Soda (Na_2O),	.08	.03	.11
Lime (CaO),	.23	.07	.06
Magnesia (MgO),	.05	.19	.19
Manganese oxid (Mn_3O_4),	.03	.03	.10
Ferric oxid (Fe_2O_3),	2.59	1.99	2.00
Alumina (Al_2O_3),	4.27	3.89	4.02
Phosphorus pentoxid (P_2O_5),	.09	.088	.025
Sulphur trioxid (SO_3),	.08	.05	.07
Carbon dioxid (CO_2),	.03	.025	.035
Volatile matter,	5.37	4.85	4.93
Nitrogen,	.11	.108	.094
Total carbon,	1.21	1.18	1.02
Total potash,	.72	1.13	1.17
Total phosphorus pentoxid,	.118	.098	.066

For the general analysis strong hydrochloric acid (sp. gr. 1. 115) was used as a solvent.

The analysis of the samples from the three plots indicates soil poor in plant-food constituents, and low in organic matter. The percentage of nitrogen is fair, but no doubt the greater portion of this was present in slowly available organic compounds. Determinations for lime requirement were not made when these samples were collected, but at the end of the first rotation (spring of 1913) samples were collected from all the plots and the lime requirement (by the Veitch method), and total nitrogen, determined. The results of these determinations are shown in Table II.

Table II—Lime Requirement and Percentage of Nitrogen of Soils from Plots that Have Received Different Quantities of Lime.

Plot No.	SPECIAL TREATMENT.	*Lime (CaO) Requirement per 2,000,000 lbs. soil.*	*Per Cent. Nitrogen.*
	Rotation 1. General Farm Crops.	*Lbs.*	
21	Nothing, ...	1,200	.077
22	0.5 Ton $CaCO_3$ per acre, ...	1,000	.075
23	1.0 " " " "	600	.075
24	2.0 " " " "	.000	.081
25	0.5 " $CaCO_3MgCO_3$ per acre, ...	600	.091
26	1.0 " " " " "	700	.093
27	2.0 " " " " "	.000	.092
	Rotation 2. General Farm Crops and Potatoes.		
28	Nothing, ...	800	.094
29	0.5 Ton $CaCO_3$ per acre, ...	800	.097
30	1.0 " " " "	600	.094
31	2.0 " " " "	100	.098
32	0.5 " $CaCO_3MgCO_3$ per acre, ...	700	.093
33	1.0 " " " " "	400	.091
34	2.0 " " " " "	300	.089
	Rotation 3. Corn, Potatoes, Market Garden Crops.		
35	Nothing, ...	1,100	.093
36	0.5 Ton $CaCO_3$ per acre, ...	800	.094
37	1.0 " " " "	600	.081
38	2.0 " " " "	400	.075
39	0.5 " $CaCO_3MgCO_3$ per acre, ...	1,100	.077
40	1.0 " " " " "	700	.080
41	2.0 " " " " "	500	.082
	Rotation 4. Forage Crops.		
42	Nothing, ...	1,200	.084
43	0.5 Ton $CaCO_3$ per acre, ...	1,100	.095
44	1.0 " " " "	700	.099
45	2.0 " " " "	600	.089
46	0.5 " $CaCO_3MgCO_3$ per acre, ...	1,100	.079
47	1.0 " " " " "	500	.067
48	2.0 " " " " "	300	.098

Considering first the lime requirement, it is to be noted that all plots, with the exception of two, were more or less acid at the end of five years. It is further to be noted that in nearly all cases the lime requirement decreased as the amount of lime applied was increased. This is graphically shown by the downward trend of the curves (Fig. 1). It is thus quite clear that one-half ton of ground limestone cannot be depended upon to keep a soil, such as we are dealing with here, in a neutral or slightly alkaline condition throughout a period of five years. It is equally clear that applications of one to two tons did have a decided influence on the soil and thus upon the crops throughout the rotation, although such applications did not in most cases, maintain the soil in a neutral or alkaline condition during the entire time. In a general way, these results are quite in agreement with the crop yields for the five years reported in the pages which follow.

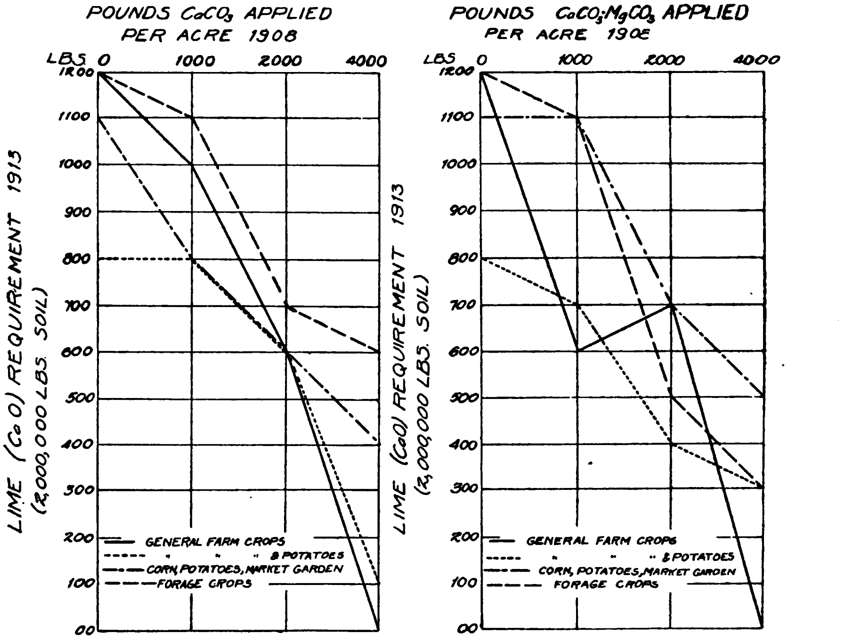

Fig. 1.—Lime applied, and lime requirement.

Turning to the per cent. of nitrogen in the soils, from the different plots, there does not appear to be any definite relationship between the amount of lime used and the per cent. of nitrogen in the soil. It is of interest, however, to note that the average per cent. is less than the average of the samples taken from the three plots in 1909. If we may accept the nitrogen determinations made on the three samples taken in 1909 as fairly representing the twenty-eight plots, and it would seem that these plots are sufficiently separated to make the samples a fair average, then it is clear that there has been a gradual loss of nitrogen from nearly all of the plots, although they have received each year a fair application of nitrogenous fertilizers and have had the benefit of two leguminous crops during the rotation. (Plots 42–48 grew one leguminous crop each year).

We would not lose sight of the fact that the crops have been steadily drawing upon the nitrogen supply, both from fertilizers and soil organic matter, and that the crops on the limed plots have in most cases drawn more heavily upon this supply than those on the check plots, but with the annual application of nitrogenous fertilizers and with two leguminous crops in the rotation, most farmers would probably expect that the nitrogen supply would at least be maintained, if not slightly increased. However, an examination of the tables giving the crop yields for the entire rotation reveals the fact that these crops have removed from the soil annually a total of about 30 to 150 pounds of nitrogen per acre, the amount usually being about 50–70 pounds. This is, in most cases, more nitrogen than was applied, and if we add to this an undetermined, but necessarily considerable amount that was lost through leaching, and remember that all the leguminous crops were removed from plots 42–48, and that those turned under on the other plots were usually small, it is at once apparent that a loss of nitrogen was almost inevitable.

These facts are mentioned here to call attention to the great difficulty that is experienced in keeping up the supply of nitrogen in the soil with constant cropping, even when nitrogenous fertilizers are used every year. This fact has already been noted in connection with field and cylinder experiments that have been conducted by this Station.*

Following the application of ground limestone in 1908, all the plots received a uniform fertilizer treatment consisting of 15 pounds of acid phosphate, 5 pounds muriate of potash and 10 pounds of fish, per plot. Early in June all plots were planted to Yellow Leaming corn and uniform cultivation given. On August the 17th, crimson clover was seeded in plots 42 to 48, and on August the 25th hairy vetch (30 lbs. per acre) on plots 21 to 41 inclusive.

The corn was harvested and weighed about the middle of October and samples dried and prepared for analysis. The results are shown in Table III, page 439, which also indicates the special treatment given each plot.

The yields from the plots receiving different lime treatment are compared with the check plot and the results reported as increase over the check in bushels of grain and pounds of forage, and nitrogen per acre.

Of the twenty-four plots that received lime, seventeen show an increase in grain ranging from 2 to nearly 13 bushels per acre; sixteen show an increase in stover ranging from 3 pounds to over 800 pounds per acre, and twenty-two show an increase in nitrogen ranging from a fraction of a pound to 19.3 pounds per acre. The average increase in bushels of grain and pounds of stover and nitrogen, per acre, for the twelve plots that received non-magnesian limestone,† and for the twelve that received magnesian limestone is as follows:

	Grain—bushels.	*Stover—pounds.*	*Nitrogen—pounds.*
Non-magnesian limestone, ...	4.21†	277.9†	8.59†
Magnesian limestone, ...	3.38	254.1	7.97

From these figures it is evident that there is no very great difference in the results so far as the two forms of lime are concerned. In yields of grain there is a difference in favor of the non-magnesian limestone of about four-fifths bushel per acre. The average increase in grain is only a little less with one-half ton than it is with two tons of limestone, and this applies to both forms. The average gain in stover is a little more with one-half ton than with two tons. The least gain in both grain and forage was made by the plots which received one ton of limestone per acre. It would therefore appear that for this crop and the given soil conditions, one-half ton per acre of either form of limestone was sufficient. The increase for this crop alone would, however, justify the application of one ton of ground limestone per acre. It is of interest to note that in almost every case the percentage of nitrogen in the dry matter is higher on the limed than on the unlimed plots.

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*Forthcoming bulletins, Dept. Soil Chem. & Bact. N. J. Agrl. College Expt. Sta.

† Plot No. 30 omitted from the average because sample was lost.

Rotations for 1909.

In 1909 the rotations were continued on the different sections as indicated in the plan already given.

Oats—Plots 21 to 27.

About the last of April these plots received a uniform fertilizer treatment of 15 pounds of acid phosphate, 5 pounds muriate of potash and 10 pounds of fish per plot, and on the following day they were seeded to oats. The oats were harvested and weighed the last of July and samples prepared for analysis. The results are reported in Table IV, page 440.

The last three columns of this table show the increase over the check, of grain, straw and total nitrogen, calculated to the acre basis. From these figures it is clear that the increases over the check are greater with the magnesian than with the non-magnesian limestone. With the non-magnesian limestone there is no increase in grain with one-half ton, and but little increase with one ton. The increase with two tons amounts to 3.53 bushels per acre. With the magnesian limestone the increase in grain is 4.35 bushels per acre with one-half ton; 5.06 bushels with one ton, and 4.90 bushels with two tons. The greatest increase in straw occurs in each case with two tons. The percentage of nitrogen in the grain is higher in every case on the limed than it is on the check plots, and this is true of the straw on four out of the six plots.

On July 31st the plots were disked and planted to cow peas. and on September 11th these were plowed under. At this time they were about eight inches high and showed no sign of inoculation. On the 14th of September the plots received 15 pounds acid phosphate, 5 pounds muriate of potash and 5 pounds of fish, and were seeded to wheat.

Potatoes—Plots 28 to 41.

These plots received a general application of fertilizer, viz.: 15 pounds of acid phosphate, 5 pounds of muriate of potash and 10 pounds of fish, and, in addition to this, there was applied 5 pounds of acid phosphate and 10 pounds of muriate of potash. The potatoes were planted about the last of April. They received the usual cultivation and were sprayed with Bordeaux and arsenate of lead two or three times during the season. The potatoes were dug and weighed August 23d and samples prepared for analysis. The results are given in Table V, page 441.

From this table it will be noted that five out of twelve plots that received lime show a loss in weight, while the gain made by the other seven is so small as to be negligible. Clearly, in this case, the lime was not beneficial to the potatoes. On September the 13th plots 28 to 34 were prepared, fertilizer applied —15 pounds acid phosphate, 5 pounds muriate of potash and 5 pounds of fish—and seeded to rye.

Oats and Peas; Millet—Plots 42 to 48.

These plots received the same fertilizer treatment that was given to plots 21 to 27, and were seeded to oats and peas on April the 27th. This crop was harvested June 29th, and on July the 7th the plots were seeded to millet, which was harvested September the 7th. The dry weights and nitrogen content of the two crops are given in Table VI, page 442.

With the exception of plot 44, the limed plots show a distinct increase over the check in both dry matter and total nitrogen. The average increase in dry matter with the magnesian limestone is more than a quarter of a ton per acre, while with the non-magnesian limestone it is less than 100 pounds. Two tons of magnesian limestone do not give any better results than one-half ton. With the non-magnesian limestone the highest yield of dry matter and nitrogen was secured with two tons. With oats and peas the percentage of nitrogen in the dry matter is higher on the limed plots than on the check plots in every case. This is not true of the millet.

On September the 14th plots 42 to 48 were prepared, fertilizer applied—15 pounds acid phosphate and 5 pounds of muriate of potash—and seeded to winter vetch.

Rotations for 1910.

In 1910 the rotations were continued in accordance with the plan.

Wheat—Plots 21 to 27.

On July the 6th the wheat on these plots was harvested, weighed, and samples taken for anaylsis. The dry weights of grain and straw and the total nitrogen recovered, together with the increase over the check, are given in Table VII, page 443.

All plots show an increase over the check, and with the exception of the grain in plot 27, the increase rises as the amount of lime is increased. The increase is greater with the magnesian than with the non-magnesian limestone, the former showing an average increase of about 7 bushels of grain, 1,000 pounds of straw and 11 pounds of nitrogen per acre. In this case the limed plots do not show a higher percentage of nitrogen in the dry matter than the check plot.

Following the wheat, the plots were planted to cow peas at the rate of 1½ bushels per acre. The stand was fair and the color good, indicating a fair degree of inoculation. They were turned under the last of August, the ground rolled and harrowed, fertilizer applied—20 pounds acid phosphate, 5 pounds muriate of potash and 2½ pounds of nitrate of soda (7½ pounds nitrate of soda to be applied as a top dressing in the spring)—and timothy and clover seeded at the rate of 10 pounds of the former and five pounds of the latter.

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the percentage of nitrogen is higher for all the limed plots than it is for the check.

Rotations for 1912.

Timothy and Clover—Plots 21 to 34.

On April the 13th, these plots received a top dressing of nitrate of soda, 7½ pounds per plot. The hay was cut and weighed July the 1st, and samples prepared for analysis. The weights and other data in connection with the crop are given in Table XIV, page 450.

All limed plots show an increase over the check. In the first section, plots 21 to 27, the greatest increase is found with the magnesian limestone, the average being about 1,191 pounds of dry matter and 11.07 pounds of nitrogen. In the second section, plots 28 to 34, the greatest increase is with the non-magnesian limestone, the average here being 725 pounds of dry matter and 8.55 pounds of nitrogen. In some cases the greatest increase occurs where the largest amount of lime was used, but this is not always true, as, for example, plots 32 to 34, where the reverse is true. With one exception, plot 23, the percentage of nitrogen is higher in the dry matter of the limed plots than it is in the check plot.

Cucumbers—Plots 35 to 41.

On May the 27th, fertilizer was applied to these plots as follows: 20 pounds acid phosphate, 10 pounds muriate of potash, 10 pounds of tankage and 8 pounds of nitrate of soda per plot, and on the following day they were planted to cucumbers. These received the usual cultivation, and, as they reached the proper stage, were gathered at four different pickings. The weights for each picking, the total weight and the increase over check are shown in Table XV, page 450.

At the first picking all plots show an increase over the check; at the second picking, all except 41 show an increase; at the third picking plots 39, 40 and 41 show no increase, while at the fourth picking only plot 36 shows an increase over the check. At the time of the third picking, it was observed that the vines were affected with something like blight; they were dying and the leaves were drying up. Plot 40 was noted as being in the worst condition. At the fourth picking, the vines were in very bad shape from blight, those on plots 38 to 41 being almost dead. This condition, no doubt, accounts for the failure of these plots to show an increase over the check towards the end of the season. The total increase on plots which received non-magnesian limestone varies from 2,700 to 4,000 pounds per acre, the greatest increase being on plot 37, which received one ton of limestone per acre. Only one of the plots which received magnesian limestone shows an increase over the check. The failure of these plots is, no doubt, due to the injury caused by the blight as already mentioned. The percentage of nitrogen in the dry matter is higher in all the limed plots than it is in the check.

Following this crop, the plots were seeded to a mixture of rye and winter vetch, consisting of 30 pounds of rye and 12 pounds of vetch, as a cover crop.

Oats and Peas; Cow Peas—Plots 42 to 48.

On April the 15th fertilizer was applied to these plots—15 pounds acid phosphate, 5 pounds muriate of potash and 10 pounds of fish—and they were seeded to oats and peas at the rate of about three bushels per acre. On account of an uneven stand, these plots were harrowed over and reseeded on May the 11th. On July the 11th the oats and peas were harvested, weighed and samples prepared for analysis. Following this crop, the plots were seeded to cow peas (New Era). These were harvested and weighed as forage on September the 30th, and samples also prepared for analysis. The results for the two crops are given in Table XVI, page 451.

For the oats and peas, all the limed plots show an increase over the check, the results from the two forms of lime being very nearly the same. It happens here in each case that the greatest increase of dry matter occurs with the smallest application of lime. With the cow peas, all limed plots, except 46, show an increase over the check. The total increase in dry weight is higher for the plots which received non-magnesian limestone than it is for those which received magnesian limestone. As good, or perhaps better, results were secured in each case with one ton as with two tons of limestone. With both crops, the percentage of nitrogen in the dry matter is invariably higher on the limed plots than on the check plots.

Amount and Value of the Increased Yield.

In Table XVII, pages 452 and 453, there is summarized the increased yield for each year according to the different amounts of non-magnesian and magnesian limestone used, and from this summary we find that the results are somewhat higher with the magnesian than with the non-magnesian limestone. With the non-magnesian limestone one ton gave about the same increase as a half ton, but two tons gave a decidedly greater increase than one ton. With the magnesian limestone one ton, in most cases, gave higher yields than one-half ton, but two tons gave yields which are, on the average, but little higher than the yields with one ton.

Table XVIII, pages 454 and 455, summarizes the increase for each year by rotations. Thus, for the general farm crop rotation, the increases for the different crops of the rotation are reported as bushels of grain and pounds of stover, straw and hay. In a similar manner, the increases for the other rotations are reported.

In order that we may arrive at the money value of the increased yields, it is necessary to find the prices of the various products for the period covered by the rotations. For the corn, wheat, oats, rye, potatoes and hay, including forage, the figures given in the Year Book of the United States Department of Agriculture (1912) for the years 1908 to 1912, inclusive, as the average farm price on December 1st, were taken. For the wheat, oats and rye straw and lima beans, the minimum wholesale New York quotations for the years in which each crop was produced, were taken. Corn stover was valued at $4.00 per ton; tomatoes at $9.00 per ton, and cucumbers at 30 cents per bushel (50 lbs.).

The increased value of the corn crop, for example, was calculated by multiplying the amount of the increase for the different plots by the price of corn for 1908. In the same way, the increased value of the other crops was calculated by taking the price of the particular crop for the year in which it was grown. The value of the increased yield for the different years and the total increased value for the five years are shown in Table XIX, pages 456 and 457.

Summary.

Four five-year rotations were carried out on twenty-eight one-twentieth acre plots, so arranged that for each rotation there was a check plot and three plots which received non-magnesian limestone at the rate of one-half, one and two tons per acre, and three plots which received like amounts of magnesian limestone.

At the close of the rotation, samples of soil were collected from the various plots and the lime requirement for each determined. The results show that nearly all the plots were acid at that time. With but few exceptions, however, the acidity decreased as the amount of applied lime increased. The check plots showed the highest lime requirement.

A comparison of the amount of nitrogen present in the surface 6 2/3 inches at the close of the rotation, with the amount present soon after the experiment was started, indicates a gradual loss of nitrogen. That is, with an annual application of nitrogenous fertilizer and with the use of two or more leguminous crops in the rotation, the nitrogen supply was not maintained.

With comparatively few exceptions, both forms of lime resulted in an increased crop yield over the check plots, the most notable exceptions being the potatoes which were grown in two of the rotations.

The yields were usually somewhat higher with the magnesian than with the non-magnesian limestone.

One ton of non-magnesian limestone gave about the same increase as one-half ton, but two tons gave a decidedly greater increase than one ton.

One ton of magnesian limestone gave, in most cases, higher yields than a half ton, but two tons did not materially increase the yield over one ton.

In the majority of cases, the dry matter of the crops from the limed plots showed a higher percentage of nitrogen than that from the unlimed plots. This is important in the case of feeding materials and human foods, inasmuch as it means a higher protein content.

The value of the total increased yield on the limed plots, as compared with the yield on the check plots, varies from a few dollars to fifty or sixty dollars per acre for the five years according to the crops in the rotation. In the majority of cases the increased value is more than twenty dollars. This should be regarded as a good investment on the money expended for the limestone—that is, the cost of one application varying from a half to two tons per acre for the entire five years.

Table III—Corn, 1908.

No.	SPECIAL TREATMENT.	GRAIN.			COBS.			STALKS.			Total Dry Matter, Cobs and Stalks, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Grain, Bu.	Stalks and Cobs, Lbs.	Nitrogen. Lbs.
21	Nothing, ...	78.15	1.31	1.024	15.21	.34	.052	130.29	.65	.847	145.50	1.923	.....	......	.....
22	0.5 Ton CaCO₃ per acre, ...	85.04	1.34	1.140	19.24	.36	.069	124.84	.72	.899	144.08	2.108	2.46	......	3.70
23	1.0 “ “ “ “ “	92.74	1.34	1.243	19.39	.29	.056	134.62	.79	1.063	154.01	2.362	5.21	170.20	8.78
24	2.0 “ “ “ “ “	100.95	1.29	1.302	20.08	.38	.076	139.22	.80	1.114	159.30	2.492	8.14	276.00	11.38
25	0.5 Ton CaCO₃-MgCO₃ per acre, ..	114.25	1.32	1.508	25.74	.38	.098	152.10	.79	1.201	177.84	2.807	12.89	646.80	17.68
26	1.0 “ “ “ “ “ “ ..	97.09	1.35	1.311	20.20	.39	.079	144.75	.82	1.187	164.95	2.577	6.76	389.00	13.08
27	2.0 “ “ “ “ “ “ ..	83.97	1.45	1.218	18.35	.41	.075	139.98	.95	1.329	158.33	2.622	2.08	256.60	13.98
28	Nothing, ...	87.07	1.27	1.106	17.35	.37	.064	135.57	.76	1.030	152.92	2.200	.....	......	.....
29	0.5 Ton CaCO₃ per acre, ...	105.60	1.41	1.489	20.34	.38	.077	174.31	.92	1.599	194.65	3.165	6.62	834.60	19.30
30	1.0 “ “ “ “ “	Lost	.....	.....	.....	.....	.....	......	.....	.....	......	.....	.....	......	.....
31	2.0 “ “ “ “ “	97.56	1.47	1.434	19.33	.32	.062	148.68	.86	1.280	168.01	2.776	3.74	301.80	11.52
32	0.5 Ton CaCO₃-MgCO₃ per acre, ..	94.96	1.51	1.434	17.97	.33	.059	124.32	.82	1.020	142.29	2.513	2.82	......	6.26
33	1.0 “ “ “ “ “ “ ..	68.06	1.59	1.082	14.52	.35	.051	138.55	.72	.998	153.07	2.131	.....	3.00	.....
34	2.0 “ “ “ “ “ “ ..	94.16	1.40	1.318	18.35	.36	.066	135.55	.74	1.003	153.90	2.387	2.53	19.60	3.74
35	Nothing, ...	89.03	1.23	1.095	17.57	.34	.060	132.99	.69	.918	150.56	2.073	.....	......	.....
36	0.5 Ton CaCO₃ per acre, ...	98.56	1.37	1.350	20.38	.32	.065	116.38	.74	.861	136.76	2.276	3.40	......	4.06
37	1.0 “ “ “ “ “	97.59	1.41	1.376	15.97	.31	.050	106.48	.77	.820	122.45	2.246	3.06	......	3.46
38	2.0 “ “ “ “ “	104.86	1.36	1.426	20.44	.30	.061	141.34	.74	1.046	161.78	2.533	5.65	224.40	9.20
39	0.5 Ton CaCO₃-MgCO₃ per acre, ..	87.26	1.39	1.213	18.72	.28	.052	120.89	.72	.870	139.61	2.135	.....	......	1.24
40	1.0 “ “ “ “ “ “ ..	103.32	1.46	1.508	21.24	.34	.072	123.10	.74	.911	144.34	2.491	5.10	......	8.36
41	2.0 “ “ “ “ “ “ ..	101.11	1.45	1.466	21.03	.36	.076	138.18	.82	1.133	159.21	2.675	4.31	173.00	12.04
42	Nothing, ...	88.32	1.30	1.148	16.71	.31	.052	105.86	.64	.678	122.57	1.878	.....	......	.....
43	0.5 Ton CaCO₃ per acre, ...	86.01	1.39	1.196	18.24	.30	.055	107.35	.69	.741	125.59	1.992	.....	60.40	2.28
44	1.0 “ “ “ “ “	84.37	1.36	1.147	18.61	.32	.060	129.62	.69	.894	148.23	2.101	.....	513.20	4.46
45	2.0 “ “ “ “ “	110.89	1.45	1.608	23.48	.28	.066	132.89	.77	1.023	156.37	2.697	8.06	676.00	16.38
46	0.5 Ton CaCO₃-MgCO₃ per acre, ..	99.81	1.33	1.327	17.59	.32	.056	142.77	.71	1.014	160.36	2.397	4.10	755.80	10.38
47	1.0 “ “ “ “ “ “ ..	84.24	1.44	1.213	17.47	.29	.051	145.38	.72	1.047	162.85	2.311	.....	805.60	8.66
48	2.0 “ “ “ “ “ “ ..	69.24	1.54	1.066	14.82	.33	.049	107.30	.72	.772	122.12	1.887	.....	......	0.18

Table IV—Oats, 1909.

Plot No.	SPECIAL TREATMENT.	GRAIN.			STRAW.			Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.		Grain, Bu.	Straw, Lbs.	Total Nitrogen, Lbs.
21	Nothing,	16.58	2.20	.365	59.64	.86	.513	.878	......	......	....
22	0.5 Ton $CaCO_3$ per acre,	16.54	2.26	.374	62.08	.87	.541	.915	.00	48.80	.74
23	1.0 “ “ “ “	17.20	2.27	.390	60.80	.83	.503	.893	.39	23.20	.30
24	2.0 “ “ “ “	22.22	2.26	.502	73.64	.84	.619	1.121	3.53	280.00	4.86
25	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	23.54	2.31	.544	79.24	.88	.697	1.241	4.35	392.00	7.26
26	1.0 “ “ “ “ “	25.66	2.32	.596	84.92	.91	.773	1.369	5.68	505.60	9.82
27	2.0 “ “ “ “ “	24.42	2.37	.579	92.82	.97	.900	1.479	4.90	663.60	12.02

Table V—Potatoes, 1909.

Plot No.	SPECIAL TREATMENT.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.	
					Dry Matter, Bu.	Nitrogen, Lbs.
28	Nothing, ...	8.16	2.30	.187	......	....
29	0.5 Ton $CaCO_3$ per acre, ...	8.78	2.08	.182	.21	....
30	1.0 " " " "	7.40	2.21	.163	......	....
31	2.0 " " " "	7.98	2.14	.170	......	....
32	0.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	8.38	2.17	.181	.07	....
33	1.0 " " " " "	6.74	2.35	.158	......	....
34	2.0 " " " " "	7.40	2.33	.172	......	....
35	Nothing, ...	5.30	2.31	.122	......	....
36	0.5 Ton $CaCO_3$ per acre, ...	5.12	2.30	.117	......	....
37	1.0 " " " "	6.08	2.37	.144	.26	4.40
38	2.0 " " " "	6.52	2.44	.159	.41	7.40
39	0.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	6.04	2.40	.144	.25	4.40
40	1.0 " " " " "	7.02	2.44	.171	.57	9.80
41	2.0 " " " " "	5.52	2.54	.140	.07	3.60

Table VI—Oats and Peas; Millet, 1909.

Plot No.	SPECIAL TREATMENT.	OATS AND PEAS.			MILLET.			Total Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Total Dry Matter.	Total Nitrogen.
42	Nothing,	94.81	2.01	1.910	62.	1.283	.7955	156.82	2.706	......	....
43	0.5 Ton $CaCO_3$ per acre,	91.99	2.19	2.015	70.	1.201	.8407	161.99	2.856	103.4	3.00
44	1.0 " " " "	67.50	2.37	1.600	70.	1.332	.9324	137.50	2.532	.0	.00
45	2.0 " " " "	90.10	2.22	2.008	76.	1.263	.9599	166.11	2.968	185.8	5.24
46	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	110.41	2.33	2.585	74.	1.116	.8258	184.43	3.411	552.2	14.10
47	1.0 " " " " "	103.85	2.49	2.585	86.	1.142	.9821	189.86	3.567	660.8	17.22
48	2.0 " " " " "	86.93	2.33	2.027	96.	1.066	1.0234	182.95	3.050	522.6	6.88

Table VII—Wheat, 1910.

Plot No.	SPECIAL TREATMENT.	GRAIN.			STRAW.			Total Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Grain, Bu.	Straw, Lbs.	Total Nitrogen.
21	Nothing, ...	50.00	1.909	.9545	92.5	.453	.4190	142.50	1.3735	......	......	......
22	0.5 Ton $CaCO_3$ per acre, ...	53.75	1.771	.9519	105.0	.414	.4347	158.75	1.3866	1.25	250.0	.262
23	1.0 " " " "	65.00	1.804	1.1726	125.0	.499	.6238	190.00	1.7964	5.00	650.0	8.458
24	2.0 " " " "	72.50	1.757	1.2738	132.5	.420	.5565	205.00	1.8303	7.50	800.0	9.136
25	0.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	72.50	1.804	1.3079	137.5	.450	.6188	210.00	1.9267	7.50	900.0	11.064
26	1.0 " " " " "	73.75	1.859	1.3710	142.5	.394	.5615	216.25	1.9325	7.92	1000.0	11.180
27	2.0 " " " " "	67.50	1.852	1.2501	151.25	.460	.6957	218.75	1.9458	5.83	1175.0	11.446

Table VIII—Rye, 1910.

Plot No.	SPECIAL TREATMENT.	GRAIN.			STRAW.			Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.		Grain, Bu.	Straw, Lbs.	Total Nitrogen, Lbs.
28	Nothing,	67.50	1.486	1.0030	203.75	.302	.6153	1.6183	......	......	....
29	.5 Ton $CaCO_3$ per acre,	75.00	1.472	1.1040	257.50	.359	.9244	2.0284	2.68	1075.0	8.20
30	1.0 " " " "	70.00	1.469	1.0283	222.50	.396	.8811	1.9094	.89	375.0	5.82
31	2.0 " " " "	80.00	1.583	1.2664	255.00	.436	1.1118	2.3782	4.46	1025.0	15.19
32	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	90.00	1.469	1.3221	267.50	.336	.8988	2.2209	8.03	1275.0	12.05
33	1.0 " " " " "	92.50	1.580	1.4615	282.50	.352	.9944	2.4559	8.92	1575.0	16.75
34	2.0 " " " " "	100.00	1.586	1.5860	302.50	.386	1.1677	2.7537	11.60	1975.0	22.70

Table IX—Tomatoes, 1910.

Plot No.	SPECIAL TREATMENT.	Green Wt., Lbs., 1st Picking.	Green Wt., Lbs., 2d Picking.	Green Wt., Lbs., 3d Picking.	Green Wt., Lbs., 4th Picking.	Green Wt., Lbs., 5th Picking.	Total Green Wt., Lbs.	Increase Over Check Calculated to Lbs per Acre.
35	Nothing, ...	41.75	88.00	118.00	39.00	386.00	672.75	......
36	.5 Ton $CaCO_3$ per acre, ...	60.625	113.25	164.00	61.00	662.00	1060.875	7762.5
37	1.0 " " " "	61.00	129.50	148.00	60.00	562.00	960.50	5755.0
38	2.0 " " " "	48.00	130.50	156.00	51.00	498.00	883.50	4215.0
39	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	51.625	119.50	154.00	50.00	577.00	952.125	5587.5
40	1.0 " " " " "	52.875	156.50	170.00	55.00	650.00	1084.375	8232.5
41	2.0 " " " " "	73.625	173.00	186.00	35.00	481.00	948.625	5517.5

Table X—Rape; Vetch, 1910.

Plot No.	SPECIAL TREATMENT.	RAPE.			VETCH.			Total Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Total Dry Matter.	Total Nitrogen.
42	Nothing, ...	75.00	1.536	1.1520	70.00	3.11	2.177	145.00	3.329	......	....
43	.5 Ton $CaCO_3$ per acre, ...	110.00	1.401	1.5411	105.00	2.855	2.996	215.00	4.5371	1400	24.162
44	1.0 " " " "	117.50	1.545	1.8154	145.00	3.225	4.676	262.50	6.4914	2350	63.248
45	2.0 " " " "	140.00	1.577	2.2078	142.50	3.262	4.648	282.50	6.8558	2750	70.536
46	.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	110.00	1.478	1.6258	135.00	3.448	4.654	245.00	6.2798	2000	59.016
47	1.0 " " " " "	115.00	1.539	1.7698	152.50	3.317	5.058	167.50	6.8278	2450	69.976
48	2.0 " " " " "	115.00	1.449	1.6664	167.50	3.413	5.718	282.50	7.3844	2750	81.108

Table XI—Oats, 1911.

Plot No.	SPECIAL TREATMENT.	GRAIN.			STRAW.			Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total. Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.		Grain, Bu.	Straw, Lbs.	Total Nitrogen, Lbs.
21	Nothing,	42.50	2.12	.901	62.50	.97	.606	1.507	......	......	....
22	.5 Ton $CaCO_3$ per acre,	43.75	2.08	.910	61.25	.84	.515	1.425	.780	......	....
23	1.0 " " " "	47.50	2.16	1.025	72.50	.816	.592	1.617	3.13	300.	2.20
24	2.0 " " " "	50.00	2.18	1.090	75.00	.81	.608	1.698	4.69	400.	3.82
25	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	55.00	2.26	1.243	85.00	.89	.756	1.999	7.81	700.	9.84
26	1.0 " " " " "	52.50	2.26	1.185	80.00	.95	.760	1.945	6.25	550.	8.76
27	2.0 " " " " "	60.00	2.26	1.356	90.00	.88	.792	2.148	10.94	900.	12.82
28	Nothing,	53.75	2.14	1.150	82.50	.77	.635	1.785	......	......	....
29	.5 Ton $CaCO_3$ per acre,	55.00	2.26	1.243	87.50	.936	.818	2.061	.78	125.	5.52
30	1.0 " " " "	50.00	2.31	1.155	82.50	.916	.756	1.911	......	......	2.52
31	2.0 " " " "	52.50	2.25	1.181	82.50	.750	.619	1.800	......	......	0.32
32	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	57.50	2.22	1.276	87.50	.810	.708	1.984	2.34	175.	3.98
33	1.0 " " " " "	57.50	2.25	1.295	87.50	.906	.793	2.088	2.34	175.	6.06
34	2.0 " " " " "	50.00	2.28	1.140	80.00	.940	.752	1.892	......	......	2.14

Table X—Rape; Vetch, 1910.

Plot No.	SPECIAL TREATMENT.	RAPE.			VETCH.			Total Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Total Dry Matter.	Total Nitrogen.
42	Nothing,	75.00	1.536	1.1520	70.00	3.11	2.177	145.00	3.329	......	....
43	.5 Ton $CaCO_3$ per acre,	110.00	1.401	1.5411	105.00	2.855	2.996	215.00	4.5371	1400	24.162
44	1.0 " " " "	117.50	1.545	1.8154	145.00	3.225	4.676	262.50	6.4914	2350	63.248
45	2.0 " " " "	140.00	1.577	2.2078	142.50	3.262	4.648	282.50	6.8558	2750	70.536
46	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	110.00	1.478	1.6258	135.00	3.448	4.654	245.00	6.2798	2000	59.016
47	1.0 " " " " "	115.00	1.539	1.7698	152.50	3.317	5.058	167.50	6.8278	2450	69.976
48	2.0 " " " " "	115.00	1.449	1.6664	167.50	3.413	5.718	282.50	7.3844	2750	81.108

Table XI—Oats, 1911.

Plot No.	SPECIAL TREATMENT.	GRAIN.			STRAW.			Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total. Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.		Grain, Bu.	Straw, Lbs.	Total Nitrogen, Lbs.
21	Nothing, ...	42.50	2.12	.901	62.50	.97	.606	1.507	......	......	....
22	.5 Ton $CaCO_3$ per acre, ...	43.75	2.08	.910	61.25	.84	.515	1.425	.780	......	....
23	1.0 " " " "	47.50	2.16	1.025	72.50	.816	.592	1.617	3.13	300.	2.20
24	2.0 " " " "	50.00	2.18	1.090	75.00	.81	.608	1.698	4.69	400.	3.82
25	.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	55.00	2.26	1.243	85.00	.89	.756	1.999	7.81	700.	9.84
26	1.0 " " " " "	52.50	2.26	1.185	80.00	.95	.760	1.945	6.25	550.	8.76
27	2.0 " " " " "	60.00	2.26	1.356	90.00	.88	.792	2.148	10.94	900.	12.82
28	Nothing, ...	53.75	2.14	1.150	82.50	.77	.635	1.785	......	......	....
29	.5 Ton $CaCO_3$ per acre, ...	55.00	2.26	1.243	87.50	.936	.818	2.061	.78	125.	5.52
30	1.0 " " " "	50.00	2.31	1.155	82.50	.916	.756	1.911	......	......	2.52
31	2.0 " " " "	52.50	2.25	1.181	82.50	.750	.619	1.800	......	......	0.32
32	.5 Ton $CaCO_3$-$MgCO_3$ per acre, ...	57.50	2.22	1.276	87.50	.810	.708	1.984	2.34	175.	3.98
33	1.0 " " " " "	57.50	2.25	1.295	87.50	.906	.793	2.088	2.34	175.	6.06
34	2.0 " " " " "	50.00	2.28	1.140	80.00	.940	.752	1.892	......	......	2.14

Table XII—Lima Beans, 1911.

Plot No.	SPECIAL TREATMENT.	LIMA-BEAN SEED.			LIMA-BEAN PODS.			Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO BU. OR LBS. PER ACRE.		
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.		Seed, Bu.	Pods, Lbs.	Total Nitrogen, Lbs.
35	Nothing,	27.00	3.002	0.811	12.25	1.323	.162	0.973	......	......	....
36	0.5 Ton $CaCO_3$ per acre,	40.00	2.902	1.161	15.50	1.532	.237	1.398	4.33	65.00	8.50
37	1.0 " " " "	37.50	3.070	1.151	15.00	1.697	.255	1.406	3.50	55.00	8.66
38	2.0 " " " "	35.75	3.045	1.089	13.00	1.557	.202	1.291	2.92	15.00	8.36
39	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	37.00	3.004	1.111	12.63	1.634	.206	1.317	3.33	7.60	6.88
40	1.0 " " " " "	37.50	3.087	1.158	12.88	1.767	.228	1.386	3.50	12.60	8.26
41	2.0 " " " " "	31.00	3.299	1.023	10.88	1.925	.209	1.232	1.33	......	5.18

Table XIII—Rye; Cow Peas, 1911.

Plot No.	SPECIAL TREATMENT.	RYE—GRAIN AND STRAW.			COW PEAS.			Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Total Dry Matter.	Total Nitrogen.
42	Nothing,	140.00	1.47	2.058	107.50	2.33	2.46	247.50	4.518	......	....
43	.5 Ton $CaCO_3$ per acre,	160.00	1.37	2.192	115.00	2.71	3.116	275.00	5.308	550.0	15.80
44	1.0 " " " "	162.50	1.57	2.551	117.50	2.79	3.278	292.50	5.829	900.0	26.22
45	2.0 " " " "	182.50	1.31	2.391	95.00	2.67	2.537	277.50	4.928	600.0	8.20
46	.5 Ton $CaCO_3$ $MgCO_3$ per acre,	160.00	1.33	2.130	75.00	2.35	1.763	235.00	3.893	......	....
47	1.0 " " " " "	160.00	1.17	1.872	90.00	2.52	2.268	250.00	4.140	50.0	....
48	2.0 " " " " "	165.00	1.20	1.98	90.00	2.66	2.394	255.00	4.374	150.0	....

Table XIV—Timothy and Clover, 1912.

Plot No.	SPECIAL TREATMENT.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
					Dry Matter.	Nitrogen.
21	Nothing,	96.25	.846	.813	......	.....
22	0.5 Ton $CaCO_3$ per acre,	110.00	.855	.941	275.0	2.56
23	1.0 " " " "	112.50	.830	.934	325.0	2.42
24	2.0 " " " "	108.75	.887	.965	250.0	3.04
25	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	143.75	.894	1.285	950.0	9.44
26	1.0 " " " " "	160.00	.887	1.419	1275.0	12.12
27	2.0 " " " " "	163.75	.910	1.490	1350.0	13.54
28	Nothing,	145.00	.855	1.240	......	.....
29	0.5 Ton $CaCO_3$ per acre,	182.50	.919	1.677	750.0	8.74
30	1.0 " " " "	171.25	.887	1.518	525.0	5.56
31	2.0 " " " "	190.00	.951	1.807	900.0	11.34
32	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	182.50	.862	1.573	750.0	6.66
33	1.0 " " " " "	161.25	.951	1.533	325.0	5.86
34	2.0 " " " " "	157.50	.958	1.509	250.	5.38

Table XV—Cucumbers, 1912.

Plot No.	SPECIAL TREATMENT.	Green Wt., 1st, Picking, Lbs.	Green Wt., 2d, Picking, Lbs.	Green Wt., 3d Picking, Lbs.	Green Wt., 4th Picking, Lbs.	Total Green Wt., Lbs.	Increase Over Check Calculated to Lbs. Per Acre.	Per Cent. Nitrogen in Dry Matter.
35	Nothing,	45	40	110	70	265	.....	2.67
36	0.5 Ton $CaCO_3$ per acre,	115	60	145	80	400	2700	2.72
37	1.0 " " " "	190	80	145	50	465	4000	2.71
38	2.0 " " " "	175	80	140	45	440	3500	2.76
39	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	175	70	110	20	375	2200	2.69
40	1.0 " " " " "	130	55	65	15	265	.....	2.86
41	2.0 " " " " "	75	40	95	15	225	.....	2.87

Table XVI—Oats and Peas; Cow Peas, 1912.

Plot No.	SPECIAL TREATMENT.	OATS AND PEAS.			COW PEAS.			Dry Matter in Crop, Lbs.	Total Nitrogen in Crop, Lbs.	TOTAL INCREASE OVER CHECK CALCULATED TO LBS. PER ACRE.	
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.			Dry Matter.	Nitrogen.
42	Nothing,	97.50	1.98	1.931	55.00	2.354	1.295	152.50	3.226	......	......
43	.5 Ton $CaCO_3$ per acre,	123.75	2.35	2.908	60.00	2.664	1.598	183.75	4.506	625.00	25.60
44	1.0 " " " "	120.00	2.45	2.940	75.00	2.945	2.209	195.00	5.149	850.00	38.46
45	2.0 " " " "	102.50	2.06	2.112	72.50	2.889	2.095	175.00	4.207	450.00	19.62
46	.5 Ton $CaCO_3$-$MgCO_3$ per acre,	120.00	2.03	2.436	51.25	2.646	1.356	171.25	3.792	375.00	11.32
47	1.0 " " " " "	113.75	2.33	2.650	60.00	2.859	1.715	173.75	4.365	425.00	22.78
48	2.0 " " " " "	103.75	2.34	2.428	70.00	3.000	2.100	173.75	4.528	425.00	26.04

Table XVII—Average Increase With Different Quantities of Non-Magnesian and Magnesian Limestone.

Plot No.	SPECIAL TREATMENT.	1908.		1909.				1910.					1911.					1912.		
		Bushels Corn.	Pounds Forage.	Bushels Oats.	Pounds Straw.	Bushels Potatoes.	Pounds Forage. [Oats & Peas, Millet.]	Bushels Wheat.	Bushels Rye.	Pounds Straw.	Pounds Tomatoes.	Pounds Forage. [Vetch & Rape.]	Bushels Oats.	Pounds Straw.	Bushels Beans.	Pounds Hulls.	Pounds Forage. [Rye & Cow Peas.]	Pounds Timothy and Clover.	Pounds Cucumbers.	Pounds Forage. [Oats & Peas, Cow Peas.]
22	0.5 Ton $CaCO_3$ per acre, ...	2.46	......	....	48.80	.....	.....	1.25	....	250.00	....	.....	.78	000.	.....	.....	.....	275.	.....	.....
29	" " " " "	6.62	834.60	....	......	.21	.....	....	2.68	1075.00	....	.....	.78	125.	.....	.....	.....	750.	.....	.....
36	" " " " "	3.40	......	....	......	.00	.....	....	....	......	7762.50	.....	....	.....	4.33	65.0	.....	.....	2700	.....
43	" " " " "	......	60.40	....	......	.....	103.40	....	....	......	....	1400	....	.....	.....	.....	550.	.....	.....	625.
	Average, ...	3.12	223.75	0.00	48.80	.10	103.40	1.25	2.68	662.5	7762.5	1400	.78	62.5	4.33	65.0	550.	512.5	2700	625.
23	1.0 Ton $CaCO_3$ per acre, ...	5.21	170.20	.39	23.20	.....	.....	5.00	....	650.00	....	.....	3.13	300.	.....	.....	.....	325.	.....	.....
30	" " " " "	Lost	Lost	....	......	.00	.....	....	.89	375.00	....	.....	0.00	000.	.....	.....	.....	525.	.....	.....
37	" " " " "	3.06	......	....	......	.26	.....	....	....	......	5755.0	.....	....	.....	3.50	55.0	.....	.....	4000	.....
44	" " " " "	......	513.20	....	......	.....	.....	....	....	......	....	2350	....	.....	.....	.....	900.	.....	.....	850.
	Average, ...	2.76	227.8	.39	23.2	.13	0.00	5.00	.89	512.5	5755.	2350	1.56	150.	3.50	55.0	900.	425.	4000	850.
24	2.0 Tons $CaCO_3$ per acre, ...	8.14	276.00	3.53	280.00	.....	.....	7.50	....	800.00	....	.....	4.69	400.	.....	.....	.....	250.	.....	.....
31	" " " " "	3.74	301.80	....	......	.00	.....	....	4.46	1025.00	....	.....	0.00	000.	.....	.....	.....	900.	.....	.....
38	" " " " "	5.65	224.40	....	......	.41	.....	....	....	......	4215.0	.....	....	.....	2.92	15.0	.....	.....	3500	.....
45	" " " " "	8.06	676.00	....	......	.....	185.80	....	....	......	....	2750	....	.....	.....	.....	600.	.....	.....	450.
	Average, ...	6.40	369.55	3.53	280.	.20	185.80	7.50	4.46	912.5'	4215.	2750	2.34	200.	2.92	15.	600.	575.	3500	450.

Table XVII—Average Increase With Different Quantities of Non-Magnesian and Magnesian Limestone—Continued.

Plot No.	SPECIAL TREATMENT.	1908.		1909.				1910.					1911.					1912.		
		Bushels Corn.	Pounds Forage.	Bushels Oats.	Pounds Straw.	Bushels Potatoes.	Pounds Forage. [Oats & Peas, Millet.]	Bushels Wheat.	Bushels Rye.	Pounds Straw.	Pounds Tomatoes.	Pounds Forage. [Vetch & Rape.]	Bushels Oats.	Pounds Straw.	Bushels Beans.	Pounds Hulls.	Pounds Forage. [Rye & Cow Peas.]	Pounds Timothy and Clover.	Pounds Cucumbers.	Pounds Forage. [Oats & Peas, Cow Peas.]
25	0.5 Ton $CaCO_3$-$MgCO_3$ per acre, ..	12.89	646.80	4.35	392.00	......	......	7.50	.....	900.00	....	.....	7.81	700.	.....	.....	.....	950.	.....	......
32	" " " " " " ..	2.82	....	....	......	.07	......	....	8.03	1275.00	....	.....	2.34	175.	.....	.....	.....	750.	.....	......
39	" " " " " " ..	......	....	....	......	.25	......	....	.....	....	5587.5	.....	.....	.....	3.33	7.6	.....	.....	2200	......
46	" " " " " " ..	4.10	755.80	....	......	......	552.20	....	.....	....	....	2000	.....	.....	.....	.....	000.	.....	.....	375.
	Average, ...	4.95	350.65	4.35	392.	.16	552.2	7.50	8.03	1087.5	5587.5	2000	5.07	437.5	3.33	7.6	.....	850.	2200	375.
26	1.0 Ton $CaCO_3$-$MgCO_3$ per acre, ..	6.76	389.00	5.68	505.60	......	......	7.92	.....	1000.00	....	.....	6.25	550.	.....	.....	.....	1275.	.....	......
33	" " " " " " ..	......	3.00	....	......	.00	......	....	8.92	1575.00	....	.....	2.34	175.	.....	.....	.....	325.	.....	......
40	" " " " " " ..	5.10	....	....	......	.57	......	....	.....	....	8232.5	.....	.....	.....	3.50	12.6	.....	.....	0000.	......
47	" " " " " " ..	......	805.60	....	......	......	660.80	....	.....	....	....	2450	.....	.....	.....	.....	50.	.....	.....	425.
	Average, ...	2.97	299.4	5.68	505.6	.28	660.8	7.92	8.92	1287.5	8232.5	2450	4.30	362.5	3.50	12.6	50.	800.	.....	425.
27	2.0 Tons $CaCO_3$-$MgCO_3$ per acre, ..	2.08	256.60	4.90	663.60	......	......	5.83	.....	1175.00	....	.....	10.94	900.	.....	.....	.....	1350.	.....	......
34	" " " " " " ..	2.53	19.60	....	......	.00	......	....	11.60	1975.00	....	.....	00.00	000.	.....	.....	.....	250.	.....	......
41	" " " " " " ..	4.31	173.00	....	......	.07	......	....	.....	....	5517.5	.....	.....	.....	1.33	00.0	.....	.....	0000.	......
48	" " " " " " ..	......	....	....	......	......	522.60	....	.....	....	....	2750	.....	.....	.....	.....	150.	.....	.....	425.
	Average, ...	2.23	112.3	4.90	663.6	.03	522.6	5.83	11.60	1575.	5517.5	2750	5.47	450.	1.33	.....	150.	800.	.....	425.

Table XVIII—Increase in Crop Yield over Check Plot.

ROTATION 1. GENERAL FARM CROPS.

Plot No.	SPECIAL TREATMENT.	1908.		1909.		1910.		1911.		1912.
		Bu. Corn.	Lbs. Stover.	Bu. Oats.	Lbs. Straw.	Bu. Wheat.	Lbs. Straw.	Bu. Oats.	Lbs. Straw.	Timothy & Clover.
22	0.5 Ton CaCO₃ per acre,	2.46	......	......	48.8	1.25	250.	0.78	......	275.
23	1.0 " " " "	5.21	170.2	0.39	23.2	5.00	650.	3.13	300.	325.
24	2.0 " " " "	8.14	276.0	3.53	280.0	7.50	800.	4.69	400.	250.
25	0.5 Ton CaCO₃-MgCO₃ per acre,	12.89	646.8	4.35	392.0	7.50	900.	7.81	700.	950.
26	1.0 " " " " "	6.76	389.0	5.68	505.6	7.92	1000.	6.25	550.	1275.
27	2.0 " " " " "	2.08	256.6	4.90	663.6	5.83	1175.	10.94	900.	1350.

ROTATION 2. GENERAL FARM CROPS AND POTATOES.

Plot No.	SPECIAL TREATMENT.	1908.		1909.	1910.		1911.		1912.
		Bu. Corn.	Lbs. Stover.	Bu. Potatoes.	Bu. Rye.	Lbs. Straw.	Bu. Oats.	Lbs. Straw.	Lbs. Timothy & Clover.
29	0.5 Ton CaCO₃ per acre,	6.62	834.6	0.21	2.68	1075.	0.78	125.	750.
30	1.0 " " " "	Lost	Lost	....	0.89	375.	......	......	525.
31	2.0 " " " "	3.74	301.8	....	4.46	1025.	......	......	900.
32	0.5 Ton CaCO₃-MgCO₃ per acre,	2.82	....	0.07	8.03	1275.	2.34	175.	750.
33	1.0 " " " " "	......	3.0	....	8.92	1575.	2.34	175.	325.
34	2.0 " " " " "	2.53	19.6	....	11.60	1975.	......	......	250.

Table XVIII—Increase in Crop Yield over Check Plot—Continued.

ROTATION 3. CORN, POTATOES, MARKET GARDEN CROPS.

Plot No.	SPECIAL TREATMENT.	1908.		1909.	1910.	1911.		1912.
		Bu. Corn.	Lbs. Stover.	Bu. Potatoes.	Lbs. Tomatoes.	Bu. Beans.	Lbs. Hulls.	Lbs. Cucumbers.
36	0.5 Ton $CaCO_3$ per acre,	3.40	......	.....	7762.5	4.33	65.0	2700.
37	1.0 " " " "	3.06	......	0.26	5755.0	3.50	55.0	4000.
38	2.0 " " " "	5.65	224.4	0.41	4215.0	2.92	15.0	3500.
39	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	......	......	0.25	5587.5	3.33	7.6	2200.
40	1.0 " " " " "	5.10	......	0.57	8232.5	3.50	12.6	....
41	2.0 " " " " "	4.30	173.0	0.07	5517.5	1.33	....	....

ROTATION 4. FORAGE CROPS.

Plot No.	SPECIAL TREATMENT.	1908.		1909.	1910.	1911.	1912.
		Bu. Corn.	Lbs. Stover.	Lbs. Forage.	Lbs. Forage.	Lbs. Forage.	Lbs. Forage.
43	0.5 Ton $CaCO_3$ per acre,	....	60.4	103.4	1400.	550.	625.
44	1.0 " " " "	8.06	513.2	....	2350.	900.	850.
45	2.0 " " " "	8.06	676.0	185.8	2750.	600.	450.
46	0.5 Ton $CaCO_3$-$MgCO_3$ per acre,	4.10	755.8	552.2	2000.	....	375.
47	1.0 " " " " "	....	805.6	660.8	2450.	50.	425.
48	2.0 " " " " "	....	....	522.6	2750.	150.	425.

Table XIX. Increase in Value Over Check Plot. All Crops.

ROTATION 1. GENERAL FARM CROPS.

PLOT NUMBER.	1908.		1909.		1910.		1911.		1912.	
	Corn.	Stover.	Oats.	Straw.	Wheat.	Straw.	Oats.	Straw.	Timothy & Clover.	Total.
22,	$1.49	.....	.....	$0.24	$1.10	$1.00	$0.35	.....	$1.62	$5.80
23,	3.16	$0.34	$0.16	0.16	4.42	2.60	1.41	$1.65	1.92	15.82
24,	4.93	0.55	1.43	1.40	6.62	3.20	2.11	2.20	1.48	23.92
25,	7.81	1.29	1.76	1.96	6.62	3.60	3.51	3.85	5.61	36.01
26,	4.10	0.78	2.30	2.53	6.99	4.00	2.81	3.03	7.52	34.06
27,	1.26	0.51	1.98	3.32	5.14	4.70	4.92	4.95	7.97	34.75

ROTATION 2. GENERAL FARM CROPS AND POTATOES.

PLOT NUMBER.	1908.		1909.	1910.		1911.		1912.	
	Corn.	Stover.	Potatoes.	Rye.	Straw.	Oats.	Straw.	Timothy & Clover.	Total.
29,	$4.01	$1.67	$0.12	$1.92	$5.38	$0.35	$0.69	$4.43	$18.57
30,	Lost	.....	.....	0.64	1.88	.....	.....	3.10	5.62
31,	2.27	0.60	.....	3.19	5.13	.....	.....	5.31	16.50
32,	1.71	.....	0.04	5.74	6.38	1.05	0.96	4.43	20.31
33,	.....	0.01	.....	6.38	7.88	1.05	0.96	1.92	18.20
34,	1.53	0.04	.....	8.29	9.88	.....	.....	1.48	21.22

ROTATION 3. CORN, POTATOES, MARKET GARDEN CROPS.

PLOT NUMBER.	1908.		1909.	1910.	1911.	1912.	
	Corn.	Stover.	Potatoes.	Tomatoes.	Lima Beans.	Cucumbers.	Total.
36,	$2.06	.....	.....	$34.93	$24.90	$16.20	$78.09
37,	1.85	.....	$0.14	25.90	20.13	24.00	72.02
38,	3.42	$0.45	0.23	18.97	16.79	21.00	60.86
39,	.....	.....	0.14	25.14	19.15	13.20	57.63
40,	3.09	.....	0.31	37.05	20.13	.....	60.58
41,	2.61	0.35	0.04	24.83	7.65	.....	35.48

Table XIX.—Increase in Value Over Check Plot. All Crops—Continued.

ROTATION 4. FORAGE CROPS.

PLOT NUMBER.	1908.		1909.	1910.	1911.	1912.	
	Corn.	Stover.	Forage.	Forage.	Forage.	Forage.	Total.
43	......	$0.12	$0.55	$8.58	$4.03	$3.69	$16.97
44	......	1.03	......	14.41	6.59	5.02	27.05
45	$4.88	1.35	0.99	16.86	4.39	2.66	31.13
46	2.48	1.51	2.93	12.26	......	2.21	21.39
47	......	1.61	3.51	15.02	0.37	2.51	23.02
48	......	......	2.78	16.86	1.10	2.51	23.25

THE INFLUENCE OF THE MECHANICAL COMPOSITION OF THE SOIL ON THE AVAILABILITY OF NITRATE OF SODA AND DRIED BLOOD.

This is a continuation of work that was begun in the spring of 1911, and the results for 1911 and 1912 have already been published.[1] For convenience, a diagram showing the plan of the experiment, together with a brief description, as presented in previous reports, are herewith submitted.

"The soil used was the typical red shale that had not been under cultivation. This was screened to remove stones, and was then mixed with sand in varying proportions as indicated in the accompanying diagram. The soil was then placed in cylinders of the type that has been in use at this Station for a number of years,[2] and to each cylinder there were added 38 gms. of precipitated chalk, twenty gms. acid phosphate, five gms. potassium chloride, five gms. potassium sulphate and two gms. magnesium carbonate. As originally planned, the five-year rotation included corn, oats, wheat and timothy. Later it was decided to substitute barley for oats, consequently the 1912 crop was barley with buckwheat as a residual crop. Each group of six cylinders is set off in three pairs, and each of the three pairs of a group receives a different fertilizer treatment, which treatment, however, is common to all groups. Thus the first and second cylinders of any group receive no fertilizer the third and fourth receive ten gms. of nitrate of soda and the fifth and sixth dried blood equivalent to the ten gms. of nitrate of soda.

First Crop—Barley, 1913.

The cylinders remained bare during the winter of 1912–13, and were prepared and seeded to barley early in May. The fertilizer treatment was the same as in previous years, except that 40 gms. of magnesian limestone were used instead of 38 gms. of precipitated chalk and 2 gms. of magnesium carbonate. The barley was harvested August the 1st, dried, weighed and samples prepared for analysis. The dry weights and analytical data are given in Table I.

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[1] Reports of Soil Chemist and Bacteriologist, New Jersey Agricultural College Experiment Station, 1911 and 1912.

[2] Bul. 221, N. J. Expt. Sta.

Plan of Experiment.

Series.	Arrangement of Cylinders.	Soil.	Treatment.
A......	① ② ③ ④ ⑤ ⑥	Shale soil..	1, 2, nothing. 3, 4, 10 gms. nitrate soda. 5, 6, 12.58 gms. dried blood.
B......	① ② ③ ④ ⑤ ⑥	10% sand...	"
C......	① ② ③ ④ ⑤ ⑥	20% "	"
D......	① ② ③ ④ ⑤ ⑥	30% "	"
E......	① ② ③ ④ ⑤ ⑥	40% "	"
F......	① ② ③ ④ ⑤ ⑥	50% "	"
G......	① ② ③ ④ ⑤ ⑥	70% "	"
H.....	① ② ③ ④ ⑤ ⑥	80% "	"
I......	① ② ③ ④ ⑤ ⑥	90% "	"
J......	① ② ③ ④ ⑤ ⑥	100% "	"

Table I—Barley, 1913.

SERIES.		Nitrogen Applied, Grams.	DRY MATTER, GRAMS.		Per Cent. Nitrogen.	NITROGEN, GRAMS.		Nitrogen Increase Over Check, Grams.	Per Cent. Nitrogen Recovered.	Relative Availability.
			Per Cylinder.	Average.		Per Cylinder.	Average.			
A	1	Nothing	38.5	33.75	1.153	.444	.384	.....	.....	.....
	2		29.0		1.114	.323				
	3	1.54	50.5	69.1	1.434	.724	.945	.561	36.43	100.0
	4		87.7		1.328	1.165				
	5	1.54	52.5	50.25	1.153	.605	.552	.168	10.91	29.9
	6		48.0		1.037	.498				
B	1	Nothing	47.5	45.25	1.134	.539	.524	.....	.....	.....
	2		43.0		1.182	.508				
	3	1.54	75.5	90.75	1.221	.922	1.160	.636	41.30	100.0
	4		106.0		1.318	1.397				
	5	1.54	72.5	75.25	1.240	.899	.892	.368	23.90	57.9
	6		78.0		1.134	.885				
C	1	Nothing	1.5*	41.0	1.076	.016*	.441	.....	.....	.....
	2		41.0		1.076	.441				
	3	1.54	91.0	89.5	1.386	1.261	1.176	.735	47.73	100.0
	4		88.0		1.240	1.091				
	5	1.54	54.5	61.75	1.143	.623	.740	.299	19.42	40.7
	6		69.0		1.240	.856				
D	1	Nothing	34.0	33.25	1.182	.402	.373	.....	.....	.....
	2		32.5		1.056	.343				
	3	1.54	82.0	81.5	1.308	1.073	1.043	.670	43.51	100.0
	4		81.0		1.250	1.013				
	5	1.54	64.5	65.25	1.279	.825	.793	.420	27.27	62.7
	6		66.0		1.153	.761				
E	1	Nothing	31.5	30.0	1.027	.324	.322	.....	.....	.....
	2		28.5		1.124	.320				
	3	1.54	79.5	82.0	1.298	1.032	1.081	.759	49.29	100.0
	4		84.5		1.337	1.130				
	5	1.54	59.5	59.0	1.143	.680	.686	.364	23.64	48.0
	6		58.5		1.182	.691				
F	1	Nothing	28.5	28.0	1.036	.295	.296	.....	.....	.....
	2		27.5		1.076	.296				
	3	1.54	95.5	92.75	1.424	1.360	1.260	.964	62.60	100.0
	4		90.0		1.289	1.160				
	5	1.54	66.0	62.75	1.163	.768	.753	.457	29.68	47.4
	6		59.5		1.240	.738				

* Omitted from average.

Table I—Barley, 1913—(Continued).

SERIES.		Nitrogen Applied, Grams.	DRY MATTER, GRAMS.		Per Cent. Nitrogen.	NITROGEN GRAMS.		Nitrogen Increase Over Check, Grams.	Per Cent. Nitrogen Recovered.	Relative Availability.
			Per Cylinder.	Average.		Per Cylinder.	Average.			
G	1	Nothing	17.5	19.25	1.192	.209	.235	.....	.....	.....
	2		21.0		1.240	.260				
	3	1.54	82.5	74.0	1.279	1.055	.956	.721	46.82	100.0
	4		65.5		1.308	.857				
	5	1.54	66.5	60.25	1.143	.760	.731	.496	32.21	68.8
	6		54.0		1.298	.701				
H	1	Nothing	16.5	18.0	1.085	.179	.193	.....	.....	.....
	2		19.5		1.056	.206				
	3	1.54	45.0	29.50	1.289	.580	.370	.177	11.49	100.0
	4		14.0		1.143	.160				
	5	1.54	60.5	56.25	1.182	.715	.693	.500	32.47	282.6
	6		52.0		1.289	.670				
I	1	Nothing	10.3	13.0	1.163	.120	.155	.....	.....	.....
	2		15.7		1.211	.190				
	3	1.54	42.6	49.10	1.357	.578	.723	.568	36.88	100.0
	4		55.6		1.560	.867				
	5	1.54	56.3	55.25	1.163	.655	.690	.535	34.74	94.2
	6		54.2		1.337	.725				
J	1	Nothing	2.0	4.50	1.143	.023	.054	.....	.....	.....
	2		7.0		1.221	.085				
	3	1.54	43.0	26.25	1.269	.546	.335	.281	18.24	100.0
	4		9.5		1.308	.124				
	5	1.54	57.0	53.75	1.289	.735	.691	.637	41.37	226.8
	6		50.5		1.279	.646				
Average.	1 2			26.600	1.127	.....	.298	.....	.....	.....
	3 4			68.445	1.318	.....	.905	.607	39.43	.....
	5 6			59.975	1.204	.....	.722	.424	27.56	.....

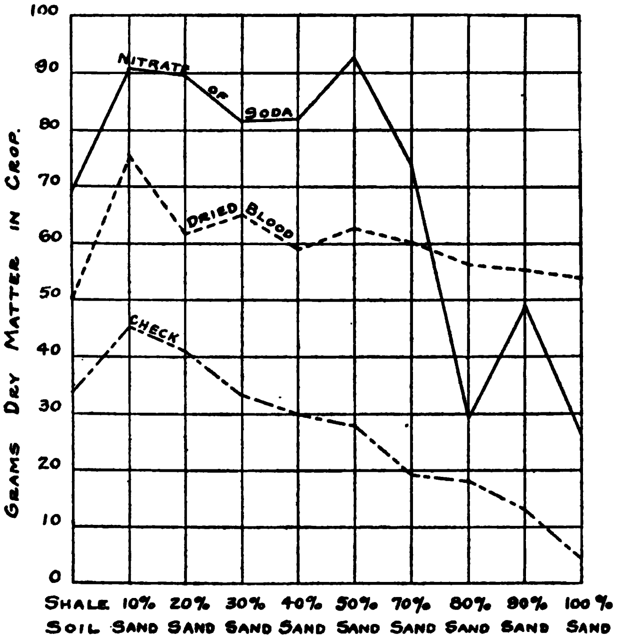

Fig. 1.—Weight of Dry Matter in First Crop—Barley.

Considering first the average dry weights, it is noted that nitrate of soda has given the highest yield for all the groups up to and including "G," which contains 70 per cent. of sand. For the last three series, which contain 80, 90 and 100 per cent. of sand respectively, the highest yield is obtained with dried blood. With the exception of one series, the percentage of nitrogen in the dry matter is higher with nitrate of soda than it is for the check cylinders or the dried blood cylinders. The percentage of nitrogen recovered and the relative availability are likewise higher with nitrate of soda for all series up to and including "G," with 70 per cent. of sand. With 80 and 100 per cent. of sand the recoveries are more than twice as high for dried blood as for nitrate of soda. With 90 per cent. of sand the recoveries for the two forms of nitrogen are very nearly the same. The highest recovery with nitrate of soda is with 50 per cent. of sand and the lowest with 80 per cent. The highest recoveries in 1911 and 1912 were with 40 per cent. of sand. Dilutions up to, and including 70 per cent. of sand do not appear to materially reduce the yield or the percentage of nitrogen in the dry matter when nitrate of soda is used. With higher percentages of sand, the yield of dry matter is decidedly reduced, though the percentage of nitrogen in the dry matter does not appear to be reduced. The dried blood shows the highest recovery with 100 per cent. of sand, and next highest with 90 per cent. The lowest recovery with dried blood occurs in series "A" with pure shale soil. The low recovery here is probably due to poor aëration, which in turn retards nitrification. With the various dilutions the recoveries from dried blood range from about 20 to something over 30 per cent. If we consider series "A" to "G," which include the shale soil and dilutions up to and including 70 per cent. of sand, we find, on an average, an availability of about 51 for blood when nitrate of soda is placed at 100; that is, a relative availability for blood of 51 per cent. With 80 to 100 per cent. of sand, the availability of dried blood is about 200, as compared with nitrate of soda at 100. Too much importance should not, however, be attached to these figures, inasmuch as the relative availability for the combined groups, which is shown in the next table, rather than the availability for one crop taken separately, should be taken as a final test.

Residual Crop of Buckwheat, 1913.

Following the barley, the cylinders were prepared and seeded to buckwheat without additional fertilizer, the intention being to utilize to the fullest extent possible, the nitrogen that was applied to the first crop. The buckwheat was harvested October the 4th, dried and weighed, and samples prepared for analysis. The weights and analytical data are given in Table II.

Table II—Residual Crop of Buckwheat and Summary for Both Crops.

SERIES.		Residual Crop.									Summary.				
		Nitrogen Applied, Grams.	Dry Matter, Grams.		Per Cent. Nitrogen.	Nitrogen, Grams.		Nitrogen Increase Over Check, Grams.	Per Cent. Nitrogen Recovered.	Relative Availability.	Total Dry Matter Both Crops, Grams.	Total Nitrogen Both Crops, Grams.	Nitrogen Increase Both Crops, Grams.	Per Cent. Nitrogen Recovered, Both Crops.	Relative Availability.
			Per Cylinder.	Average.		Per Cylinder.	Average.								
A	1	NO NITROGEN APPLIED TO THE RESIDUAL CROP.	32.5	39.75	1.362	.443	.565	....	.....	......	73.50	.949	....	.....	.....
	2		47.0		1.459	.686									
	3		32.1	32.1	1.478	.474	.485	.000	0.00	......	101.2	1.430	.561	36.43	100.0
	4		32.1		1.546	.496									
	5		53.7	53.7	1.440	.773	.773	.208	13.51	......	103.95	1.325	.376	24.42	67.0
	6		5.0*		2.406	.120*									
B	1		41.0	40.45	1.382	.567	.561	....	.....	......	85.70	1.085	....	.....	.....
	2		39.9		1.391	.555									
	3		49.2	44.2	1.417	.697	.632	.071	4.61	100.00	134.95	1.792	.707	45.91	100.0
	4		39.2		1.443	.566									
	5		54.0	53.5	1.401	.757	.745	.184	11.95	259.22	128.75	1.637	.552	35.85	78.1
	6		53.0		1.382	.732									
C	1		34.5	34.5	1.420	.490	.480	....	.....	......	75.5	.921	....	.....	.....
	2		34.5		1.362	.470									
	3		23.9	29.55	1.578	.377	.442	.000	0.00	......	119.05	1.618	.735	47.73	100.0
	4		35.2		1.440	.507									
	5		40.9	36.45	1.401	.573	.511	.031	2.01	......	98.2	1.251	.330	21.43	44.9
	6		32.0		1.401	.448									
D	1		34.0	27.7	1.347	.458	.341	....	.....	......	60.95	.714	....	.....	.....
	2		21.4		1.044	.223									
	3		30.5	29.95	1.188	.362	.395	.054	3.51	100.00	111.45	1.438	.724	47.02	100.0
	4		29.4		1.456	.428									
	5		49.8	46.65	1.333	.664	.641	.300	19.48	555.0	111.90	1.434	.720	46.75	99.4
	6		43.5		1.420	.618									
E	1		32.3	25.1	1.420	.459	.356	....	.....	......	55.1	.678	....	.....	.....
	2		17.9		1.411	.253									
	3		25.6	27.7	1.459	.374	.407	.051	3.31	100.00	109.7	1.488	.810	52.60	100.0
	4		29.8		1.478	.440									
	5		45.0	46.75	1.324	.596	.633	.277	17.99	543.5	105.75	1.319	.641	41.63	79.1
	6		48.5		1.379	.669									
F	1		33.1	33.55	1.362	.451	.456	....	.....	......	61.55	.752	....	.....	.....
	2		34.0		1.353	.460									
	3		35.2	37.8	1.475	.519	.541	.085	5.52	100.00	130.55	1.801	1.049	68.12	100.0
	4		40.4		1.391	.562									
	5		40.0	38.25	1.382	.553	.476	.020	1.30	23.5	101.00	1.229	.477	30.98	45.5
	6		36.5		1.092	.399									

* Omitted from average.

Table II—Residual Crop of Buckwheat and Summary for Both Crops—(Continued).

Series.		Residual Crop.									Summary.				
		Nitrogen Applied, Grams.	Dry Matter, Grams. Per Cylinder.	Dry Matter, Grams. Average.	Per Cent. Nitrogen.	Nitrogen, Grams. Per Cylinder.	Nitrogen, Grams. Average.	Nitrogen Increase Over Check, Grams.	Per Cent. Nitrogen Recovered.	Relative Availability.	Total Dry Matter Both Crops, Grams.	Total Nitrogen Both Crops, Grams.	Nitrogen Increase Both Crops, Grams.	Per Cent. Nitrogen Recovered, Both Crops.	Relative Availability.
G	1	NO NITROGEN APPLIED TO THE RESIDUAL CROP.	27.2	26.85	1.382	.376	.351	....	.....	......	46.10	.586	....	.....	.....
	2		26.5		1.227	.325									
	3		26.5	31.0	1.478	.392	.441	.090	5.84	100.00	105.0	1.397	.811	52.66	100.0
	4		35.5		1.379	.490									
	5		36.9	37.7	1.411	.521	.504	.153	9.93	170.00	97.95	1.235	.649	42.14	80.0
	6		38.5		1.266	.487									
H	1		25.0	24.1	1.411	.353	.341	....	.....	......	42.1	.534	....	.....	.....
	2		23.2		1.420	.329									
	3		18.5	24.85	1.391	.257	.352	.011	0.71	100.00	54.35	.722	.188	12.20	100.0
	4		31.2		1.430	.446									
	5		38.2	39.35	1.324	.506	.547	.206	13.38	1884.5	95.60	1.240	.706	45.85	375.8
	6		40.5		1.449	.587									
I	1		15.0	17.25	1.437	.216	.262	....	.....	......	30.25	.417	....	.....	.....
	2		19.5		1.575	.307									
	3		12.5	14.8	1.556	.195	.223	.000	0.00	......	63.9	.946	.568	36.88	100.0
	4		17.1		1.469	.251									
	5		25.5	26.55	1.551	.396	.409	.147	9.54	......	81.8	1.099	.682	44.28	120.1
	6		27.6		1.527	.421									
J	1		5.7	6.0	1.527	.087	.092	....	.....	......	10.5	.146	....	.....	.....
	2		6.3		1.536	.097									
	3		8.7	6.85	1.507	.131	.102	.010	0.65	100.00	33.1	.437	.291	18.89	100.0
	4		5.0		1.430	.072									
	5		17.5	13.5	1.478	.259	.198	.106	6.88	1058.5	67.25	.889	.743	48.25	255.4
	6		9.5		1.430	.136									
Average.	1		....	27.527	1.391	.....	.381	....	.....	......	......	....	....	.....	.....
	2														
	3		....	27.880	1.449	.....	.402	.037	2.41	......	......	....	.644	41.844	100.0
	4														
	5		....	39.240	1.440	.....	.544	.163	10.60	......	......	....	.588	38.158	91.2
	6														

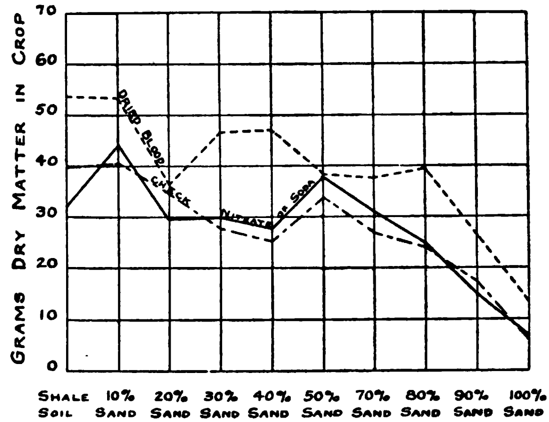

Fig. 2.—Weight of Dry Matter in Residual Crop—Buckwheat.

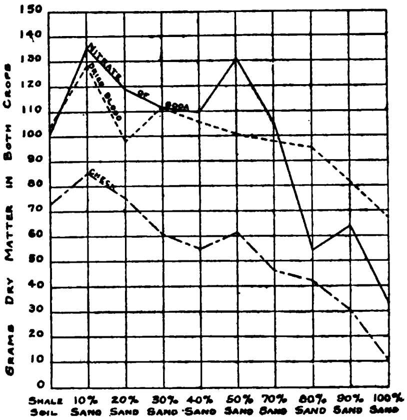

Fig. 3.—Weight of Dry Matter—Both Crops.

Throughout the series, the average weight of dry matter is highest from those cylinders that received nitrogen in the form of dried blood.[1] This is easily explained on the ground that the nitrate of soda, being readily soluble, was either largely utilized by the first crop or lost in the drainage water. The average weights of dry matter from the check cylinders and the nitrate of soda cylinders do not differ very much, though the figures for the nitrate cylinders are usually a little above those for the check cylinders. The reverse was true in 1912. The question may be raised as to why the check cylinders, which have received no nitrogen, should give a yield almost equal to the yield from the cylinders which have regularly received nitrate of soda. An explanation for this is, no doubt, to be found in the fact that the nitrate of soda stimulated the growth of the first crop, forming a more extensive root system, with the result that the nitrogen of the soil organic matter was utilized to a fuller extent in the nitrate cylinders than in the check cylinders. Thus, during the growing period of the second crop, there was more nitrifiable organic matter at the disposal of the crop on the check cylinders than there was at the disposal of the crop on the nitrate cylinders, and, consequently, more available nitrogen, because the nitrate of soda had practically all disappeared with the first crop. Such a practice would, undoubtedly, tend towards a gradual decrease in the yield from year to year on the check cylinders, and this appears to be the case, for the yield from these cylinders is less in almost every instance for 1913 than for 1912, while on the other hand, the yield from the nitrate of soda cylinders is about the same for the two years. In dilutions up to and including 70 per cent. of sand, the percentage of nitrogen in the dry matter is, in most cases, slightly higher for the nitrate cylinders than it is for the check or dried blood cylinders. With 80, 90 and 100 per cent. of sand, the percentages of nitrogen in the dry matter differ but little with the different treatments. It would appear that there was a small amount of the nitrate of soda that that was not utilized by the first crop in nearly all cylinders having a dilution not exceeding 70 per cent. of sand. The fact that nearly all the nitrate of soda cylinders show recoveries of 3 to 5 per cent. tends to confirm this view. There was practically no recovery of nitrogen from the nitrate cylinders containing 80 to 100 per cent. of sand. The highest recovery with nitrate of soda for the residual crop is 5.84, with 70 per cent. of sand, followed closely by series "F," which contains 50 per cent. of sand. Series "A," "C" and "I" failed to show any recovery of nitrogen from nitrate with this crop. The highest recovery from dried blood was 19.48 per cent. from series "D," containing 30 per cent. of sand, followed closely by series "E" with 40 per cent. of sand. The lowest recovery was 1.30 per cent. of nitrogen from series "F." The average recovery from nitrate of soda for this crop is 2.41 per cent., and from dried blood 10.06 per cent.

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[1] On account of the abnormally poor growth of the crop on cylinder 6, series "A," the weight of dry matter and nitrogen were omitted from the average.

The total dry matter, total nitrogen, the increase over the check, the percentage of nitrogen recovered and the relative availability, for both crops, are shown in the last four columns of Table II. The average recovery from the nitrate of soda for all series is 41.84 per cent., while the average from the dried blood is 38.16 per cent. Placing the availability of nitrate nitrogen at 100, the average availability of dried blood is, for the two crops 91.2. If, however, we consider series "A" to "G," that is, the shale soil and dilutions up to and including 70 per cent. of sand, the figures are materially changed. The average recovery from nitrate of soda then becomes 50 per cent., and from dried blood 34.74 per cent., which gives an availability of about 70 for dried blood when nitrate is 100. Likewise, considering separately series "H," "I" and "J," we find an average availability of about 250 for dried blood when nitrate is placed at 100. These figures plainly indicate a higher recovery of nitrogen, and, therefore, higher availability, from nitrate of soda

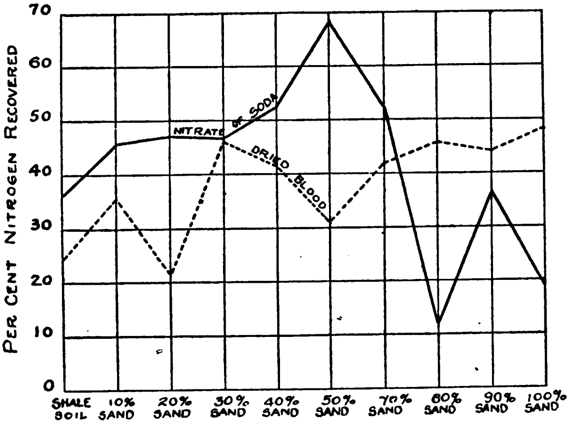

Fig. 4.—Recovery of Nitrogen in Both Crops.

than from dried blood, in shale soil and in dilutions up to and including 70 per cent. of sand. In mixtures containing 80 to 90 per cent. of sand, and in pure sand, blood shows a higher recovery, and, therefore a higher availability, than nitrate of soda.

From these results it seems fair to conclude that, even if the two forms of nitrogen should be sold at the same price (the price of dried blood is now higher than that of nitrate of soda), nitrate of soda would be more economical than dried blood for the average soil, that is, for clays, loams and even sandy loams. For loamy sands and sands, on the other hand, it is quite evident that dried blood will give better results than nitrate of soda for the reason that the nitrate is more easily leached out under such conditions.

It is of interest to compare the theoretical amounts of nitrogen which should be recovered from the organic matter of the shale soil where sand was introduced (as calculated from the recovery from pure shale soil), with the net amounts that were actually recovered. Referring to Table II, column headed "Nitrogen in both crops," it is seen that there was recovered from the check cylinders, where pure shale soil was used, .949 gram of nitrogen. From the corresponding cylinders with pure sand there was recovered .146 gram of nitrogen, made up of traces that may have been in the sand, that which was contained in the seed, and any that may have been fixed by non-symbiotic bacteria. The difference between .949 gram and .146 gram is .803 gram, which represents the actual net recovery from the shale soil cylinder. Since the check cylinders of series "B" were 90 per cent. shale instead of pure shale soil, the theoretical recovery from this should be 90 per cent. of .803, which is .722. The actual amount of nitrogen recovered in the combined crops from the check cylinders of series "B" was 1.085 grams, and subtracting from this the .146 gram (combined recovery from the check and pure sand) leaves .939 gram, which represents the net recovery from the shale soil of series "B." In a similar way, the theoretical and actual recoveries for the combined crops, from the humus of the shale soil, may be calculated for each series, and, when tabulated, are as follows:

TABLE —. NITROGEN RECOVERED FROM SHALE SOIL IN THE COMBINED CROPS.

Composition of the Soil.	*Theoretical Amount of Nitrogen Recovered. Gms.*	*Actual Amount of Nitrogen Recovered. Gms.*
100% Shale Soil,	.803	.803
90% " "	.722	.939
80% " "	.642	.775
70% " "	.562	.568
60% " "	.481	.532
50% " "	.401	.606
30% " "	.241	.440
20% " "	.161	.388
10% " "	.080	.271
100% sand.		

From these figures it is seen that the actual net recovery of nitrogen from the humus of the shale soil, where this was diluted with a certain percentage of sand, was greater in every instance than the theoretical amount as calculated from the shale soil alone. This clearly indicates an improved condition of the soil due to the introduction of sand. On account of better aeration the soil organic matter is more completely nitrified. From the above table it will be noted that the highest actual recovery from the organic matter of the shale soil occurred with 10 per cent. of sand. The greatest amount of total nitrogen recovered was 1.8 grams in series "F," where nitrate of soda was used.

SUMMARY.

1. This report is a continuation of work that was begun in 1911.
2. When sand was mixed with shale soil (Penn Loam) in varying proportions, the yield of dry matter and the percentage of nitrogen recovered from nitrate of soda were greater with 10 to 70 per cent. of sand than they were with the shale soil alone, or with 80, 90 or 100 per cent. of sand. The highest yield of dry matter and percentage of nitrogen recovered occurred with 50 per cent. of sand.
3. With dried blood the yield of dry matter and the percentage of nitrogen recovered were higher in pure sand, and in all dilutions, than with the shale soil alone.
4. In no case was the yield of barley (first crop) on the check cylinders as high as the yields on the cylinders that received nitrate of soda and dried blood.
5. With the residual crop of buckwheat no nitrogen was recovered from three of the series that received nitrate of soda, while comparatively small amounts were recovered from the other series. With dried blood there was some recovery in all series, the highest occurring in series "D" with 30 per cent. of sand.
6. With the first crop, barley, the highest average yield of dry matter and nitrogen were from the nitrate of soda cylinders; with the residual crop of buckwheat the highest average yield of dry matter and nitrogen were from

the dried blood cylinders. With the combined crop the average yield of dry matter and nitrogen were very nearly the same for the two nitrogenous materials. For the check cylinders, the average yield of dry matter and nitrogen were slightly higher with the residual crop than with the first crop.

7. The fact that the average yield of dry matter and nitrogen for the combined crops were about the same with nitrate of soda and dried blood does not necessarily lead to the conclusion that these two materials are equally good for all types of soil. In the discussion it has been shown that for the shale soil, and dilutions up to and including 70 per cent. of sand, the average availability of dried blood is 70.6 when nitrate of soda is placed at 100, while, with 80 to 100 per cent. of sand, the average availability of dried blood is 250 when nitrate of soda is placed at 100. From this it must be inferred that for all except very sandy soils nitrate of soda shows a higher availability than dried blood.

8. The average percentage of nitrogen in the dry matter is higher for both crops with nitrate of soda than with dried blood or with the check cylinders.

9. With most soils we need not expect much residual effect from moderate applications of nitrate of soda. We may expect some residual effect from dried blood in nearly all cases.

10. The actual net recovery of nitrogen from the humus of the shale soils to which varying amounts of sand had been added is greater in every case than the theoretical amount as calculated from the recovery from pure shale soil. Mixing sand with heavy soils permits better aëration and drainage and results in a more complete utilization of the nitrogen in the organic matter.

THE CONTINUOUS GROWING OF WHEAT AND RYE—1913.

The plan of this experiment was fully described in the Annual Report for 1912[1] and the results for the first five years were there given in detail. For convenience, the general plan may be briefly re-stated.

Plan of Experiment.

The experiment is being conducted on four one-twentieth acre plots, designated as numbers 68, 69, 70 and 71. The soil is a gravelly loam fairly uniform in quality. Previous to starting this experiment the land had been used for general farming, but had not been heavily manured and had not been limed for more than twenty years. When the experiment was begun, all plots were limed at the rate of 2,000 pounds of ground limestone per acre. The plots also receive annually an application of minerals (acid phosphate and muriate of potash) at the rate of 400 pounds of acid phosphate and 200 pounds of muriate of potash per acre. Tests made of samples of soil collected from these plots in the spring of 1913 showed a lime requirement of four to six hundred pounds of lime (CaO) per two million pounds of soil, and in the fall of 1913, before seeding to wheat and rye, they received ground limestone at the rate of 4,000 pounds per acre.

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[1] Report Soil Chemist and Bacteriologist, N. J. Agricultural College Experiment Station, 1912, p. 261.

The arrangement of plots, with the treatment given, is as follows:

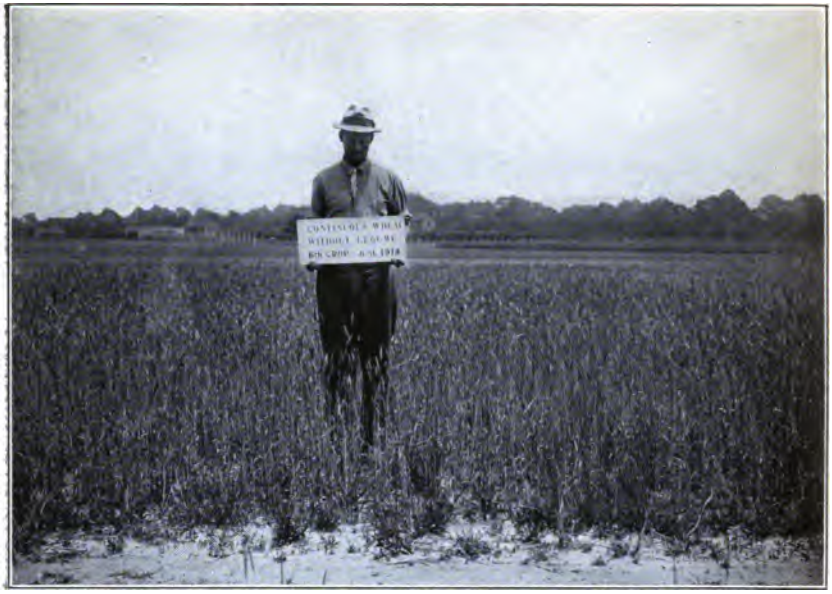
Plot 68, Rye alone, ...Minerals
" 69, Wheat alone, ...Minerals
" 70, Rye followed each year by cow peas (or Soy beans) as green manure + minerals.
" 71, Wheat followed each year by cow peas (or Soy beans) as green manure + minerals.

Each year the stubble is disked on Plots 70 and 71 soon after harvesting the crop, and cow peas are drilled in, Plots 68 and 69 remaining in stubble. About two or three weeks before seeding to wheat and rye, the green manure crop on Plots 70 and 71 is turned under and Plots 68 and 69 are also prepared for seeding.

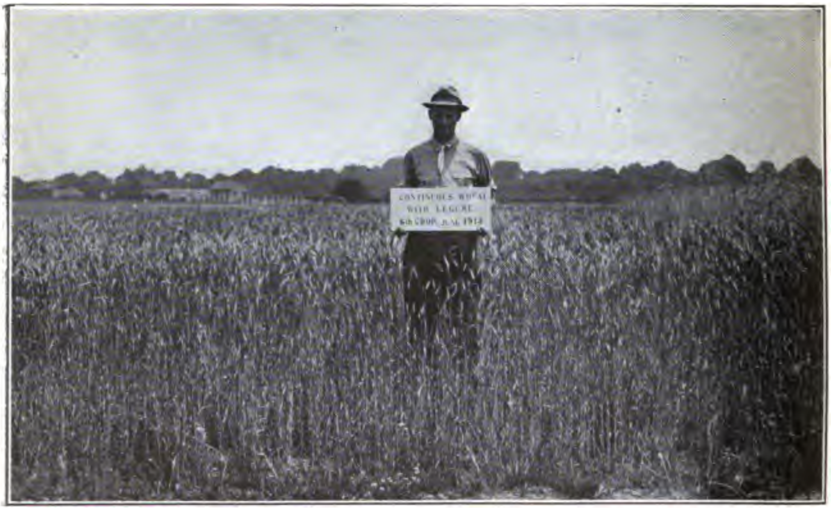
It may be noted here that the crop of cow peas which was turned under in the fall of 1912 was poor, due to a diseased condition which was probably caused by the continuous growing of this crop on the same plots. Soy beans were used in 1913 instead of cow peas.

Crop for 1913.

The rye was harvested about the last of June and the wheat the first of July. The dry weights of grain and straw and the amount of nitrogen recovered in the crop are shown in Table V.



Plot No. 70. Continuous wheat without legume.



Plot No. 72. Continuous wheat with legume.

Table V—Wheat and Rye, With and Without Legumes.

Plot No.	CROP.	GRAIN PER PLOT.			STRAW PER PLOT.			PER ACRE.		
		Dry Weight, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Dry Weight, Lbs.	Per Cent. Nitrogen.	Total Nitrogen, Lbs.	Bushels Grain.	Pounds Straw.	Pounds Nitrogen.
68	Rye, alone, ...	26.87	1.621	.436	63.75	.324	.207	8.96	1275	12.86
69	Wheat, alone, ...	18.75	2.137	.401	51.25	.620	.318	6.25	1025	14.38
70	Rye, followed by Soy Beans, ...	53.12	1.698	.902	153.75	.372	.572	17.71	3075	29.48
71	Wheat, followed by Soy Beans, ...	40.42	2.213	.894	127.50	.467	.595	13.47	2550	29.78

From this table it will be noted that the yields were all low this year, but it is significant that the yields of grain are just about twice as great from the legume plots as they are from the plots which did not grow a legume. The yields of straw and nitrogen on the plots with the wheat and rye alone did not amount to half as much as the yields on the legume plots. It is to be noted further that the leguminous crops have a slightly increased proportion of nitrogen in the rye and wheat grain and likewise in the rye straw, but not in the wheat straw. The results for 1913 bear out the results obtained in 1911 and 1912 and make it quite clear that even a leguminous crop which has not attained full development, may add to the soil enough humus and nitrogen to more than double the yield as compared with plots which have grown no legume. It must be admitted, however, that the yields on all plots this year are entirely too low. The low yields on the legume plots may be due, in part at least, to the poor growth of the 1912 crop of cow peas, while the low yield on the other plots is no doubt due to the gradual depletion of nitrogen and humus of the soil.

THE INFLUENCE OF BACTERIA SUPPLIED IN MANURE, ON THE DECOMPOSITION OF GREEN MANURE (LEGUME AND NON-LEGUME).

An account of the first five years of this work was given in the report for 1912. It was there stated that the object of the experiment is to study the bacterial influence of cow manure on the decomposition of green manures. The quantities of manure are purposely kept small in order that the influence of the fertilizing constitutents in the manure may be reduced to a minimum. The experiment also contemplates a comparison of legumes with non-legumes in continuous corn growing.

For convenience a brief statement of the plan as given in last year's report is inserted here.

Plan of the Experiment.

"The experiment is conducted on one-twentieth acre plots, on land that is largely a gravelly loam, varying from sandy to clayey phases, although apparently the differences are not great. The soil is not what would be called a fertile soil, and is without doubt deficient in nitrogen, this being the chief limiting factor. At the beginning of the experiment ground limestone, at the rate of one ton per acre, was applied to all the plots by means of a fertilizer drill, and each plot also received fifteen pounds of acid phosphate, five pounds of potassium chloride, and ten pounds of fish. The special treatment is as follows:

Plot 49, corn followed by crimson clover as green manure, nothing.
" 50, " " " " " " " " + 50 lbs. of manure.
" 51, " " " " " " " " + 100 lbs. of manure.
" 52, " " " " " " " " + 200 lbs. of manure.
" 53, " " " rye as green manure, nothing.
" 54, " " " " " " " + 50 lbs. of manure.
" 55, " " " " " " " + 100 lbs. of manure.
" 56, " " " " " " " + 200 lbs. of manure.

The manure is preferably that which has been well rotted, and is broadcasted over the green manure before plowing under."

Crop of 1913.

The cover crops which were seeded in the fall of 1912 made only a fair growth during the winter. Early in May it was noted that the crimson clover and vetch on plot 49 appeared in scattered clumps; plot 50 was slightly better than 49; plot 51 was the poorest of the legume plots, while 52 was the best.

In the non-legume section the rye was thin but fairly uniform and about waist high at the time of plowing.

The manure was spread over the plots before plowing, in accordance with the original plan. The ground was further prepared, finely ground limestone applied at the rate of two tons per acre, and fertilizer applied—15 pounds acid phosphate, 5 lbs. muriate and 11¼ pounds tankage (=10 pounds fish) per plot. Reed's yellow dent corn was planted June 3d. Five cultivations were given, the cover crops being seeded at the time of the last cultivation..

The corn was harvested about the last of September. After partial drying, the corn was husked and weighed and samples prepared for analysis. The yields of dry matter and nitrogen are shown in Table VI.

Table VI—Yield of Corn, 1913.

LEGUME SECTION.

Plot No.	SPECIAL TREATMENT.	GRAIN.			COBS.			STOVER.			Grain, Dry Weight, Lbs.	Stover and Cobs, Dry Weight, Lbs.	Total Nitrogen, Lbs.	Increase of Nitrogen Over Check.
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.				
49	Nothing, ...	93.75	1.573	1.475	17.50	.476	.083	128.75	.825	1.062	93.75	146.25	2.620	Check
50	50 lbs. Cow Manure, ...	96.25	1.505	1.449	15.00	.544	.082	132.50	.913	1.210	96.25	147.50	2.741	.121
51	100 " " "	90.00	1.437	1.293	15.00	.388	.058	121.25	1.000	1.213	90.00	136.25	2.564	.000
52	200 " " "	92.50	1.592	1.473	16.25	.350	.057	127.50	.942	1.201	92.50	143.75	2.731	.111
	Average, ...	93.12	1.527	1.422	15.94	.440	.070	127.50	.920	1.172	93.12	143.44	2.664	.077

NON-LEGUME SECTION.

Plot No.	SPECIAL TREATMENT.	GRAIN.			COBS.			STOVER.			Grain, Dry Weight, Lbs.	Stover and Cobs, Dry Weight, Lbs.	Total Nitrogen, Lbs.	Increase of Nitrogen Over Check.
		Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.	Dry Matter, Lbs.	Per Cent. Nitrogen.	Nitrogen, Lbs.				
53	Nothing, ...	57.50	1.447	0.832	8.75	.398	.035	107.50	.748	0.804	57.50	116.25	1.671	Check
54	50 lbs. Cow Manure, ...	82.50	1.408	1.162	12.50	.418	.052	146.25	.893	1.306	82.50	158.75	2.520	.849
55	100 " " "	76.25	1.622	1.237	13.75	.437	.060	127.50	.864	1.101	76.25	141.25	2.398	.727
56	200 " " "	62.50	1.563	0.977	11.25	.447	.050	108.75	1.097	1.193	62.50	120.00	2.220	.549
	Average, ...	69.69	1.510	1.052	11.56	.425	.049	122.50	.901	1.101	69.69	134.06	2.202	.708

The yield of corn (grain) is very nearly the same as for 1912, but the yield of stover is about 50 per cent. greater on the legume section and about 60 per cent. greater on the non-legume section than in 1912. It is especially noteworthy, too, that the percentage of nitrogen in the dry matter—grain, cobs and stover—is higher than in 1912. From results secured in liming experiments, an account of which is included in this report, it seems safe to conclue that this increase in nitrogen content is due in part, at least, to the heavy application of ground limestone made before planting the corn. It is also to be noted that in most cases the percentage of nitrogen is higher in the dry matter of the legume section than in the non-legume section. This is in accord with results obtained in previous years.

The Influence of the Manure.

In the legume section the plots that receive manure show little or no increase over the check plot. This is undoubtedly to be attributed to the presence of the legume. The extra amount of nitrogen furnished in this way largely obscures any effect which the bacteria furnished by the manure may have, and the better the catch of legumes, the more completely will this influence be obscured. Attention has already been called to this fact in connection with the report for the first five years.

This does not hold true of the non-legume section. In every case the plots receiving manure show an increase over the check plot. The increase is not, however, proportional to the amount of manure applied; indeed more often the increase is less with two tons per acre of manure, than with one-half ton. This seems sufficient proof that the increase is not to be attributed to the actual fertilizing constituents which the manure carries.

It would thus appear that the bacteria conveyed in small quantities of cow manure are instrumental in bringing about a more rapid decomposition of the green manure crop, and thus make available more nitrogen for the succeeding crop. If the green manure crop consists of legumes, the additional nitrogen thus secured tends to obscure the effects of the manure.

VEGETATION EXPERIMENTS.

American Rock-Potash Fertilizer.

A quantity of the above-named material having come to the Experiment Station with the request that it be given a trial along with other potash materials, it was decided to use it in some pot experiments which were carried out during the summer of 1913. According to information received from the Institute of Industrial Research, Washington, D. C., this material is prepared from insoluble minerals which contain potash in the form of silicates. Through a process which has not been made public, a fertilizing material is prepared which contains 4.3 per cent. of water-soluble potash (5.6 per cent. total potash) and 15.2 per cent. of total lime. Two separate pot experiments were conducted, clean white sand being used in one and soil in the other.

Experiment No. 1.

The soil used in this experiment was a gravelly loam rather poor in nitrogen, phosphoric acid and available potash and lime. Pots holding ten pounds of soil were used. The general fertilizer treatment for each pot (they were run in triplicate) was as follows:

4	gms.	Acid Phosphate
2	"	Nitrate of Soda
5	"	Calcium Carbonate
0.5	"	Magnesian Sulphate
0.25	"	Ferric Sulphate

The amount of potash in two grams of potassium sulphate was taken as the standard, and such quantities of the other materials were used as would give this amount of actual potash, so that all pots received the same amount of potash.

The fertilizers were thoroughly mixed with the soil and the whole transferred to the pot. The moisture was maintained at about 15 per cent. The crop grown was buckwheat. The special potash treatment for each series of three pots, together with the dry weights of buckwheat (grain and straw together) are shown in Table I.

TABLE I.—EXPERIMENT NO. 1.

POT NO.	SPECIAL TREATMENT.	DRY MATTER. GRAMS. Per Pot.	DRY MATTER. GRAMS. Average.
1 2 3	No Potash,	15.2 9.5 11.0	11.90
4 5 6	2 grms. K_2SO_4; 50.39% K_2O,	10.8 14.1 13.6	12.83
7 8 9	23.44 grms. Rock-Potash; 4.3% K_2O,	8.2 7.5 8.2	7.97
10 11 12	5.444 grms. Kainit; 18.57% K_2O,	8.0 6.0 5.0	6.33
13 14 15	26.8 grms. Wood Ashes; 3.76% K_2O,	9.5 12.5 14.9	12.30
16 17 18	23.44 grms. Rock-Potash; 4.3% K_2O,	5.2 4.0 5.0	4.73
19 20 21	1.60 grms. K_2CO_3; Pure,	12.5 12.5 13.6	12.87
22 23 24	1.937 grms. KCl; 52.02% K_2O,	12.7 11.0 11.5	11.73

The highest yields were obtained with potassium sulphate and potassium carbonate, there being practically no difference between the two materials; the yield with wood ashes was very nearly as high. The rock-potash and kainit both appear to have depressed the yield. Why this is so is not clear, but the results would seem to indicate the presence of some toxic compound in both these substances.

The fact that the check pots have given yields slightly greater than the yield with muriate of potash may mean that the presence of an abundant supply of lime has resulted in making available the potash of the soil to such an extent that the applied potash does not have a pronounced effect. The results with the sulphate would, however, seem to indicate that there is not enough potash naturally present in the soil for maximum results.

Experiment No. 2.

This experiment was a repetition of No. 1, with the exception that the pots in this case held twenty pounds of clean white sand. The moisture was maintained at about ten per cent. Buckwheat was grown as in Experiment No. 1. The special potash treatment given and the yields of dry matter are shown in Table II.

TABLE II.—EXPERIMENT NO. 2.

POT NO.	TREATMENT.	DRY MATTER. GRAMS.	
		Per Pot.	*Average.*
1 2	No Potash, ...	7.9 6.2	7.05
3 4	2 grms. K 2 SO_4; 50.39% K_2O, ...	9.2 8.0	8.60
5 6	23.44 grms. Rock-Potash; 4.3% K_2O,....	6.7 4.7	5.70
7 8	5.444 grms. Kainit; 18.57% K_2O, ...	3.2 6.4	4.80
9 10	26.8 grms. Wood Ashes; 3.76% K_2O, ..	9.2 9.7	9.45
11 12	23.44% grms. Rock-Potash; 4.3% K_2O,	6.0 6.0	6.00
13 14	1.60 grms. K_2CO_3; Pure, ...	9.2 10.2	9.70
15 16	1.937 grms. KCl; 52.02% K_2O, ...	7.5 8.2	7.85

Potassium carbonate and wood ashes have again given the highest yields, followed closely by potassium sulphate. Here also the kainit and rock-potash appear to have had a depressing effect upon the yield of dry matter, the yield in each case being less than the yield from the check pot. The yield with the muriate is less than with the sulphate, but greater than the check. Field tests must be carried out before definite conclusions may be arrived at with regard to the toxic effect of the rock-potash. In each instance the yields are lower with kainit than with rock-potash. The rock potash is a low-grade material as compared with muriate and sulphate and, therefore, comparatively large amounts must be used when it is substituted for these salts, and it is quite possible that in this way other soluble compounds are introduced in sufficient amounts to prove toxic.

Comparison of Basic Slag with Other Phosphates.

In co-operation with the Basic Slag Committee of the Association of Official Agricultural Chemists, two experiments were conducted to test the availability of the phosphoric acid in basic slag in comparison with the phosphoric acid in other phosphates. The samples, with the analysis, were furnished by the Basic Slag Committee. The experimental work was done by the Experiment Station. Experiment No. 1 was conducted in pots holding 20 pounds of clean white sand, practically devoid of available plant food; and No. 2 in pots holding 18 pounds of gravelly loam, poor in nitrogen and organic matter, and containing about .07 to .08 per cent. of P_2O_5, soluble in strong hydrochloric acid. The general treatment for each pot in the two experiments was as follows: 4 gms. high grade K_2SO_4, 3 gms. $NaNO_5$, 5 gms. $CaCO_3$, 0.5 of a gm. $MgSO_4$ and 0.25 of a gm. $Fe_2\ (SO_4)\ _3$. The special treatment for the two experiments was also the same, so that the only difference was in the soil and the amount of moisture supplied, the moisture in the sand being maintained at about 10 per cent., and in the loam about 15 per cent. The amount of P_2O_5 in the 5.82 grms. of acid phosphate was taken as the standard, and such quantities of the other phosphate materials taken as would give an equal amount of P_2O_5. One exception to this should be noted. For pots 15 and 16, in both experiments, enough of the rock phosphate was taken to give just double the amount of P_2O_5 contained in the 5.82 gms. of acid phosphate. The average of the four pots without phosphate was taken as the check in each case. The crop grown was buckwheat, and this was harvested when the grain was beginning to ripen, so that grain and straw were not separated.

Experiment No. 1.

The results obtained in experiment No. 1, with the sand, are shown in Table III.

Table III—Comparison of Phosphates; Experiment No. 1.

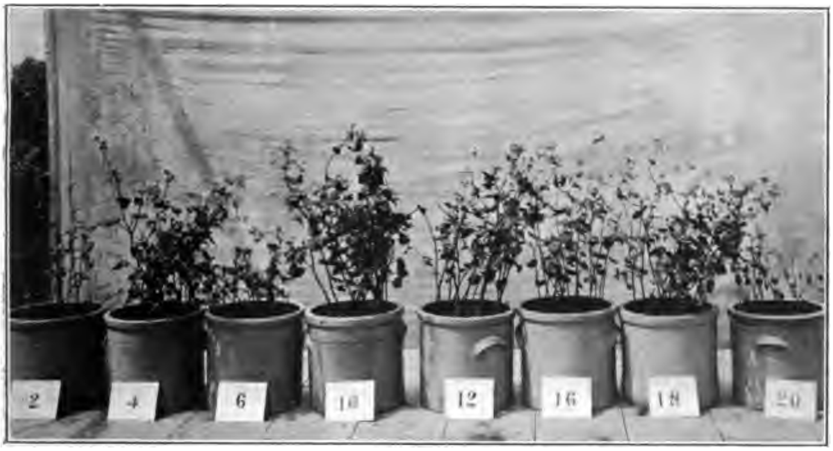
Pot No.	SPECIAL TREATMENT.	Dry Weight Per Pot. Gms.	Average. Gms.	Increase Over Check. Gms.
1, 2	No Phosphate	2.9 2.8	..... 2.85	....
3, 4	5.82 Gms. Acid Phosphate 17.82% P_2O_5	16.7 15.5	..... 16.10	..... 13.50
5, 6	4.965 " Sodium Phosphate 20.87% "	2.5 4.1	..... 3.30	..... .70
7, 8	5.665 " Basic Slag A 18.30% "	13.7 14.6	..... 14.15	..... 11.55
9, 10	5.445 " Basic Slag B 19.04% "	12.0 21.0	..... 16.50	..... 13.90
11, 12	7.785 " Basic Slag C 13.31% "	15.2 14.7	..... 14.95	..... 12.35
13, 14	6.537 " Basic Slag D 15.86% "	17.2 13.5	..... 15.35	..... 12.75
15, 16*	7.050 " Blue Rock Phosphate 29.4 % "	10.0 9.7	..... 9.85	..... 7.25
17, 18	2.241 " Double Super Phosphate 46.25% "	18.5 17.0	..... 17.75	..... 15.15
19, 20	No Phosphate	2.5 2.2	..... 2.35	....

* Nos. 15 and 16 received double the amount of P_2O_5 contained in the 5.82 gms. of acid phosphate.

The acid phosphate gave an increase of 13.5 gms. of dry matter over the check pots. The average increase made by the basic slag samples is 12.64 gms., which is within a gram of the increase

PLATE A.

Experiment No. 1. Comparison of different phosphates.



No Phos.

Acid Phos.

Sodium Phos.

Slag B.

Slag C.

Rock Phos.

Double Super Phos.

No Phos.

made by the acid phosphate. This, it must be admitted, is a very good showing for the slag, when it is remembered that the sand contained practically no organic matter. The plants in pots to which sodium phosphate was applied were very much depressed in growth and showed signs of injury, due to toxic compounds. No. 6, in the accompanying photograph, shows the extent of this injury. It will be noted that the plants are but little better than those in the check pots. The injury was evidently physiological, and may have been due to the presence of readily soluble sodium compounds. The greatest increase was made by the double superphosphate. The rock phosphate made little more than half the increase made by the acid phosphate.

Experiment No. 2.

The results secured in experiment No. 2, where soil was used instead of sand, are given in Table IV.

Table IV—Comparison of Phosphates; Experiment No. 2.

Pot No.	SPECIAL TREATMENT.	Dry Weight Per Pot. Gms.	Average. Gms.	Increase Over Check. Gms.
1, 2	No Phosphate	22.5 25.7	..... 24.10	..... Check
3, 4	5.82 Gms. Acid Phosphate 17.82% P_2O_5	30.8 29.9	..... 30.35	..... 6.77
5, 6	4.965 " Sodium Phosphate 20.87% "	28.5 30.8	..... 29.65	..... 6.07
7, 8	5.665 " Basic Slag A 18.30% "	32.8 29.5	..... 31.15	..... 7.57
9, 10	5.445 " Basic Slag B 19.04% "	33.0 37.4	..... 35.20	..... 11.62
11, 12	7.785 " Basic Slag C 13.31% "	27.6 28.0	..... 27.80	..... 4.22
13, 14	6.537 " Basic Slag D 15.86% "	39.5 27.2	..... 33.35	..... 9.77
15, 16*	7.050 " Blue Rock Phosphate 29.40% "	23.8 25.0	..... 24.40	..... .82
17, 18	2.241 " Double Super Phosphate 46.25% "	32.7 30.7	..... 31.70	..... 8.12
19, 20	No Phosphate	23.6 22.5	..... 23.05	..... Check

---

* Nos. 15 and 16 received double the amount of P_2O_5 contained in the 5.82 gms. of acid phosphate.

Here all the phosphate treatments have given an increase over the check, the greatest increase being given by basic slag B, which is highest in percentage of P_2O_5, and the lowest by the rock phosphate. The average increase made by the basic slag samples is 8.3 gms. of dry matter, which is more than the increase made by either the acid phosphate, sodium phosphate or double super-phosphate. In this experiment the sodium phosphate did not appear to have any injurious effect on the growth of the plants. As a possible explanation for this, it is suggested that the soil may have the power to absorb or counteract toxic compounds, while the sand does not have this power. It may be noted that the slag which gave an increase of only 4.22 gms. over the check is the one which shows the lowest percentage of P_2O_5.

DESCRIPTION OF WIRE CAGE USED FOR THE PROTECTION OF POT EXPERIMENTS.

The wooden-frame cage constructed over the Pot Experimental Benches having blown down in February, 1913, it was decided to replace it with a more substantial iron structure. The dimensions are practically the same as those of the old cage—48 feet 4 inches in length, 21 feet 10 inches in width and 8 feet high.

Almost the entire frame construction is of 2½-inch by ¼-inch angle iron, the parts being bolted together by 1-inch by ½-inch machine bolts. The angle iron, bolts, etc., were purchased of a local hardware company, while all of the work was done at odd times by the field assistants of the Soil Department, none of whom had had any previous experience in iron construction. Through the courtesy of the Manager of the College Farm, the well-equipped farm blacksmith shop was placed at the disposal of the Department.

All the angle iron was purchased in 20-foot lengths, the only length obtainable from our source of supply. This was right for making the upright posts, but 22-foot lengths for the ends and 24-foot lengths for the sides would have saved much cutting and joining. All the cutting was done cold by using an anvil, a blacksmith's cold chisel, and a 10-pound sledge. The holes were drilled with a wall press drill driven by hand power.

The upright posts, of which there are 16, were made 10 feet in length. All the holes deemed necessary were drilled before the pieces were taken from the shop, and an anchor piece one foot in length, of the same material, was bolted to the lower end of each post.

The foundation trench was dug two feet deep by one foot wide. The posts were placed and leveled and held in position by scaffolding while the trench was filled to within three inches of the top with concrete. The distance between the posts on the sides is about 9 feet 8 inches, while at the ends it is about 7 feet. The gateway, which is placed at the middle of one end, is 6 feet 9 inches in width. The horizontal pieces were fitted across the top of the posts, and bolted securely to each one. Where splices were necessary, 1½-inch by ¼-inch flat iron was used. To support the wire covering and to brace the structure, a single length of 3-inch by ⅜-inch T-iron 21 feet 10 inches long was placed across the cage from the top of each of the three intermediate side posts to its mate at the opposite side. These three cross pieces have no middle support (such support should, however, be provided). They are bolted to the under side of the horizontal side pieces at their point of juncture with the posts.

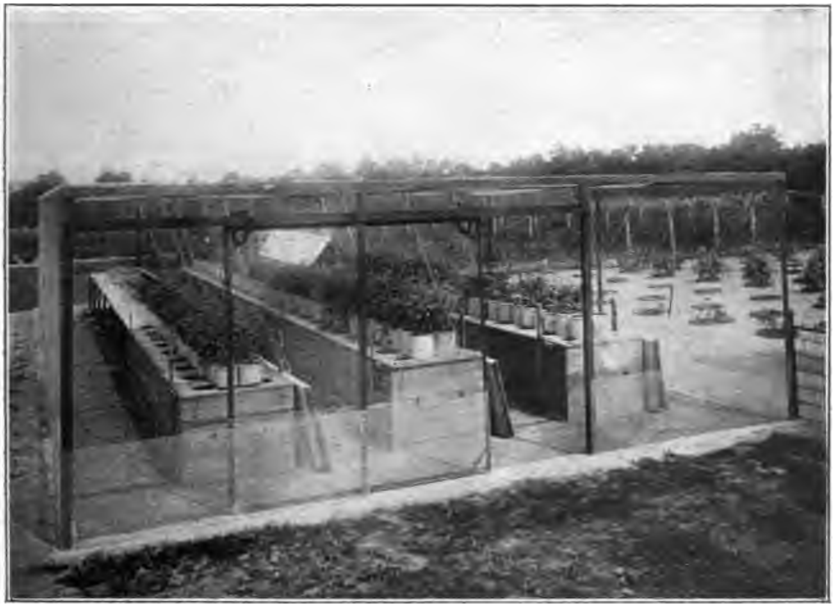
The frame complete, the wire covering was put on. To keep out mice a heavy galvanized wire 30 inches wide and with ¼-inch mesh was placed around the bottom. This was embedded in 3 inches of concrete. The remainder of the cage was covered with ordinary 1-inch mesh chicken wire 6 feet wide. The wire covering was fastened to the iron work with copper wire and with staples driven through double holes previously drilled for the purpose. The gate, 7 feet by 7 feet, was made of 2½-inch by ¼-inch angle iron and swung on an overhead track.

Since the work on the cage was done at odd times, it is difficult to arrive at the exact cost of the structure. The material alone cost approximately one hundred and twenty-five dollars, one hundred of which was for the angle iron, wire, bolts, etc., while the remaining twenty-five was for the cement. It would be safe to say that the entire cost of the cage was not more than two hundred and twenty-five dollars.

The benches for pots were originally constructed of boards. It is the intention, however, to gradually replace these with benches the framework of which is made of angle iron similar to that used in the construction of the cage. In constructing these benches, uprights are set in concrete, and angle iron rails are fastened along the top of these in such manner that boards can be laid across to form the bench. The far end of the bench shown on the left in the photograph was made in this way.

At night and during rainstorms the pots are protected by means of canvas-covered frames, as shown at the back of the cage on the right. If desired these frames may be drawn up by means of cords and pulleys, or two persons may easily lift them and place them over the pots. They are secured in place by hooks.

The accompanying photograph supplements this description.



Wire cage used for the protection of pot experiments.

UNIV. OF MICH.

REPORT

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Soil Chemist and Bacteriologist

OF THE

New Jersey Agricultural College Experiment Station

New Brunswick, N. J.

BY

JACOB G. LIPMAN

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Report of the Soil Chemist and Bacteriologist.

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POT EXPERIMENTS ON THE AVAILABILITY OF NITROGEN IN MINERAL AND ORGANIC COMPOUNDS.

A large number of pot experiments dealing with the availability of nitrogen in different materials have already been reported by this Station. In the majority of these experiments it has been customary to use one or two grams of nitrate of soda for twenty pounds of soil or sand, and an equivalent amount of nitrogen from other sources. Since the nitrogen of nitrate of soda is more readily available than that of sulphate of ammonia and organic nitrogenous materials it is possible that a moderate application of this would place the other materials, when used in equivalent amounts, at a disadvantage. It seemed worth while therefore to try a large amount of nitrate with correspondingly large amounts of the other materials, and in experiment No. 1, 4 grams of the nitrate were used with equivalent amounts of sulphate of ammonia, tankage and cotton seed meal.

EXPERIMENT No. 1. Earthenware pots holding twenty pounds of sand were used. Each pot received 4 grams acid phosphate, 2 grams potassium sulphate, 5 grams ground limestone, 0.5 gram magnesium sulphate, and 0.25 gram iron sulphate. In addition to this treatment nitrogenous fertilizer materials were applied as indicated in the table. The moisture was maintained at about 10 per cent. Twenty-two barley seeds were planted in each pot and the crop grown to maturity. The weight of dry matter produced and percentage of nitrogen recovered are shown in Table I.

Table I—The Recovery of Nitrogen From Different Materials.

		FIRST CROP—BARLEY.					RESIDUAL CROP—BARLEY.				
Pot No.	SPECIAL TREATMENT.	Nitrogen applied mgs.	Dry matter gms.	Per cent. nitrogen.	Average nitrogen mgs.	Per cent. nitrogen recovered.	Dry matter gms.	Per cent. nitrogen.	Average nitrogen mgs.	Per cent. nitrogen recovered.	Per cent. nitrogen recovered, both crops.
1			0.8	0.767			0.5	0.687			
2	No Nitrogen		0.7	0.698	5.39		0.5	0.828	3.98		
3			0.6	0.856			0.5	0.872			
4		616	10.5	3.039			3.5	1.933			
5	4 gms. NaNO3 (15.4%)	616	10.5	3.029	314.32	50.15	6.0	1.560	82.31	12.71	62.86
6		616	9.2	3.324			5.9	1.452			
7		616	13.8	2.390			4.5	0.961			
8	2.92 gms. (NH2)4 SO4 (21.07%)	616	13.7	2.498	331.24	52.90	4.5	0.971	43.70	6.45	59.35
9		616	11.2	2.872			5.0	0.883			
10		616	11.8	1.878			3.6	0.893			
11	5.77 gms Tankage (10.68%)	616	10.8	2.115	223.25	35.37	3.9	0.961	32.43	4.62	39.99
12		616	9.8	2.242			3.0	0.922			
13		616	12.5	1.485			2.6	1.383			
14	9.62 gms. C. S. Meal (6.4%)	616	12.5	1.495	186.05	29.33	3.0	1.285	37.48	5.44	34.77
15		616	12.5	1.485			3.0	1.265			

The highest average yield of dry matter is with ammonium sulphate, and the next highest with cotton seed meal. It is of especial interest to note the wide variation in nitrogen content of the dry matter. The average for the check pots is 0.77 per cent. The average for the nitrate pots is 3.13 per cent. which is more than four times the amount for the check pots. The average for the ammonium sulphate pots is 2.587 per cent., for the tankage 2.078 per cent. and for the cotton seed meal 1.488 per cent.

This confirms work already reported and indicates that where available nitrogen is present the plant will take it up even to the point of injury. Thus, in a way, the plant measures the availability of the materials, though the amount applied is an important factor to be considered. The higher yield of dry matter with ammonium sulphate more than offsets the lower percentage of nitrogen and gives a higher percentage recovery. The yield of dry matter with cotton seed meal is higher than with tankage, but the percentage of nitrogen in the dry matter with tankage is enough higher to give a higher recovery than with cotton seed meal.

Residual Crop.

A second crop of barley was grown in these pots without further fertilizer treatment. The results from this second crop are shown in tabular form as a part of Table I. It will be noted that the yield of dry matter is, in all cases where the nitrogenous fertilizers were used, much less than in the first crop. Likewise the percentage of nitrogen is in most cases less than half what it was in the first crop. The cotton seed meal seems to prove an exception, however, for here the percentage of nitrogen is nearly as high as in the first crop, indicating a fair supply of readily available nitrogen. Apparently the cotton seed meal decomposed slowly and gave up less of its nitrogen to the first crop than did the other materials. The results with the other materials make it quite certain that with distinctly diminishing nitrogen supply there is not only a diminished yield but also a lower percentage of nitrogen in the dry matter.

The recovery of nitrogen from nitrate of soda with this crop is approximately double the recovery from ammonium sulphate, which makes the total recovery from nitrate 62.86, while the total recovery from ammonium sulphate is only 59.35. In the residual crop the recovery from cotton seed meal is 5.44 per cent. as against 4.62 for the tankage.

The results indicate that on account of the ready availability of the nitrogen of nitrate of soda it is not quite fair to compare recoveries from this with recoveries from equivalent amounts of materials not so readily available, if the application is a small or moderate one, and if only one crop is grown. If large applications of ammonium sulphate are made, resulting in an immediate supply of readily available nitrogen from the ammonium sulphate, or if the residual crop is taken into consideration then an equivalent amount of nitrate should have no unfair advantage over the ammonium sulphate.

Experiment No. 2. In this experiment twenty pounds of sand were used as in No. 1, but nitrate of soda was the only mineral nitrogenous material used, the other materials all being organic. The general conditions were the same except that each pot received double the amount of minerals applied in Experiment No. 1, and the crop was buckwheat instead of barley, the latter being grown in the winter and the former in the summer.

In this instance 3 grams of nitrate of soda were used and equivalent amounts of the organic materials as indicated in the table.

Table II—The Recovery of Nitrogen From Different Materials.

Pot No.	SPECIAL TREATMENT.	BUCKWHEAT—1913.					BARLEY 1914 (RESIDUAL CROP).				Per cent. nitrogen recovered, both crops.
		Nitrogen applied mgs.	Dry matter gms.	Per cent. nitrogen.	Aver. nitrogen mgs.	Per cent. nitrogen recovered.	Dry matter gms.	Per cent. nitrogen.	Average nitrogen mgs.	Per cent. nitrogen recovered.	
1	No Nitrogen	....	0.9	1.443	13.22	....	2.1	0.767	15.57	....	....
2			0.8	1.661			2.0	0.718			
3			0.7	1.910			2.2	0.738			
4	3 gms Na NO_3	462	15.2	2.112	305.18	63.19	6.2	0.885	55.41	8.62	71.81
5			15.0	2.006			6.2	0.885			
6			14.5	2.025			6.6	0.856			
7	16.985 gms. Alfalfa Meal	462	8.0	1.693	130.69	25.43	5.5	0.777	40.56	5.41	30.84
8			7.3	1.725			5.2	0.738			
9			*2.5	*2.287			*7.9	*0.856			
10	12.126 gms. Green Rye	462	10.0	1.754	158.82	31.52	5.8	0.757	47.81	6.98	38.50
11			9.3	1.512			7.0	0.767			
12			9.3	1.725			5.9	0.777			
13	3.774 gms. Dried Blood	462	12.6	1.802	212.69	43.17	4.6	0.787	42.12	5.74	48.91
14			11.7	1.841			5.9	0.777			
15			9.8	1.996			5.5	0.806			
16	7.213 gms. Cotton Seed Meat	462	8.2	2.122	177.20	35.49	5.9	0.777	42.74	5.88	41.37
17			*4.2	*2.535			*9.0	*0.797			
18			10.7	1.686			5.1	0.777			

*Omit from Average.

With two exceptions the .triplicate weights agree quite well, the nitrate of soda giving the highest average yield and the dried blood second highest. With the exceptions noted the percentages of nitrogen are also fairly concordant.

The nitrate gives a uniform percentage slightly above two per cent., while the average for the dried blood is a little below two per cent.

The recovery with nitrate of soda is 63.19 per cent. and with dried blood it is 43.17 per cent. It is of interest to note that these figures are very close to results obtained in earlier work at this Station,[1] both pot and cylinder experiments, and also to the results obtained in Germany.

The recoveries for the other materials agree quite well with recoveries heretofore obtained with vegetable nitrogenous materials.

Residual Crop.

Following the buckwheat the pots were seeded to barley without the further addition of fertilizers, the aim being to utilize the remaining nitrogen. The results constitute a part of Table II.

Again the recovery with nitrate of soda is highest though all recoveries are low, indicating that the available nitrogen was largely utilized by the first crop. We should naturally expect the residual crop to show higher recoveries with the organic materials than with nitrate of soda, but this is not so in this case. Just why more of the organic nitrogenous material should not become available for the second crop is not clear. Further work along this line is being carried on. It is very probable that had the soil been subjected to the leaching action of rain the recovery from nitrate with the second crop would have been lower.

EXPERIMENT NO. 3. For this experiment pots holding twenty pounds of sand were used. Nitrate of soda was used alone and in combination with vegetable and animal organic matter. Where used alone 4 grams of the nitrate were applied to each pot and the organic materials were used in equivalent amounts. When used in combination one half the nitrogen was taken from nitrate and one half from the organic materials. All pots received the double portion of mineral materials as in Experiment No. 2. Buckwheat was planted for the first crop and barley for the second or residual crop. The crops were grown to maturity but grain and straw were harvested together. The results are reported in Table III.

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[1] Factors Relating to the Availability of Nitrogenous Plant-Foods. Bulletin No. 251 N. J. Agricultural Experiment Station, pages 44–47.

Table III—The Recovery of Nitrogen From Different Materials.

Pot No.	SPECIAL TREATMENT.	Nitrogen applied mgs.	BUCKWHEAT—1913. Dry matter gms.	BUCKWHEAT—1913. Per cent nitrogen.	BUCKWHEAT—1913. Average nitrogen mgs.	BUCKWHEAT—1913. Per cent. nitrogen recovered.	BARLEY—1913–14. Dry matter gms.	BARLEY—1913–14. Per cent nitrogen.	BARLEY—1913–14. Average nitrogen mgs.	BARLEY—1913–14. Per cent. nitrogen recovered.	Per cent. nitrogen recovered, both crops.
1	No Nitrogen.	....	0.5	1.550	7.65	....	2.2	0.806	17.03	....	....
2			0.5	1.507			2.0	0.816			
3	4.00 grams Na NO3.	616	21.0	2.103	438.25	69.90	5.2	0.816	36.53	3.17	73.07
4			21.1	2.061			3.8	0.806			
5	22.65 grams Alfalfa Meal.	616	10.3	1.521	166.26	25.75	5.5	0.915	54.32	6.05	31.80
6			9.5	1.851			5.3	1.100			
7	16.17 grams Green Rye.	616	9.6	2.093	201.70	31.50	6.5	0.806	53.04	5.85	37.35
8			9.9	2.045			7.0	0.767			
9	5.03 grams Dried Blood.	616	13.7	1.957	216.48	33.90	5.2	0.777	55.20	6.20	40.10
10			7.0	2.355			8.0	0.875			
11	5.77 grams High Grade Tankage.	616	11.7	2.074	224.49	35.20	6.3	0.816	55.28	6.21	41.41
12			12.1	1.705			6.2	0.954			
13	8.58 grams Low Grade Tankage.	616	9.2	1.957	240.22	37.75	7.8	0.944	52.75	5.80	43.55
14			15.2	1.938			4.1	0.777			
15	2.00 grams Na NO3.	616	13.5	2.054	257.72	40.60	4.7	1.277	72.89	9.07	49.67
16	11.32 grams Alfalfa Meal.	616	12.6	1.890			8.0	1.072			
17	2.00 grams Na NO3.	616	17.0	1.986	332.69	52.77	5.0	0.816	41.05	3.90	56.67
18	8.08 grams Green Rye.	616	17.9	1.831			5.0	0.826			
19	2.00 grams Na NO3.	616	15.2	2.054	316.02	50.06	7.2	0.826	50.77	5.48	55.54
20	2.52 grams Dried Blood.	616	14.8	2.161			5.7	0.738			
21	2.00 grams Na NO3.	616	15.7	2.112	333.23	52.85	5.1	0.973	51.98	5.67	58.52
22	2.88 grams H. G. Tankage.	616	16.0	2.093			6.5	0.836			
23	2.00 grams Na NO3.	616	15.5	2.122	331.13	52.51	6.0	0.728	34.59	2.85	55.36
24	4.28 grams L. G. Tankage.	616	17.2	1.938			3.6	0.718			
25	4.00 grams Na NO3.	616	11.8	2.141	272.48	42.99	9.9	1.560	128.83	18.15	61.14
26			14.5	2.016			6.6	1.564			

With two or three exceptions the duplicate weights are concordant. The highest yield is with nitrate of soda It is of interest to note that the average weights where organic matter alone was used are without exception lower than the average weights where the same amount of nitrogen is used in the form of nitrate of soda and organic matter combined. With slight exception the percentages of nitrogen run uniformly close to two per cent. However, where no nitrogen was applied it is only a little over one and one-half per cent. The highest recovery 69.90 per cent. is with nitrate of soda and it is again to be noted that the recovery with the combined nitrate and organic matter is invariably higher than the recovery with organic materials alone, the average for the former being 49.76 and for the latter 32.82. This points to increased efficiency through such combination and bears out work previously reported which seemed to show that the presence of nitrates in the soil stimulates the ammonification of organic nitrogenous matter. With nitrogen as nitrate of soda costing no more than nitrogen as organic matter, and sometimes less, depending upon the source of the organic nitrogen, the results of this experiment seem to fully justify the farmer in using nitrate of soda along with his organic matter, if conditions require that he use some commercial organic materials.

Residual Crop.

With the idea of utilizing the nitrogen as fully as possible, barley was seeded as a second or residual crop to be grown during the winter of 1913-14. No further fertilizers were applied. The second part of the table gives the results obtained with this residual crop.

It will be noted that the yields of dry matter are small in all pots. It is to be futher noted, however, that the yields from the pots which received the organic materials alone, and the organic materials combined with nitrate of soda, gave a higher yield than the nitrate alone. This is unquestionably to be attributed to the residual effects of the organic fertilizers, which, on account of gradual decomposition, were not utilized to so great an extent by the first crop. The percentage of nitrogen in the barley is in most cases less than one per cent., which is scarcely half what it is in the buckwheat. This clearly points to a deficiency of available nitrogen for the residual crop, since in other experiments barley has shown percentages of nitrogen varying from two to three per cent. when an abundance of available nitrogen was supplied. Attention may be called to an average slightly above one per cent. where alfalfa meal was used with the nitrate of soda. This points to alfalfa as furnishing more readily available nitrogen than the other organic materials.

The percentage of nitrogen recovered is low in all cases, except with nitrate of soda in pots 25 and 26, and this high residual recovery must be attributed to the fact that the large application of nitrate to the first crop somewhat injured the plants so that they did not develop and utilize the nitrogen to the fullest extent possible. It was noted on one or two occasions that the plants in these pots showed signs of injury from excessive amounts of nitrogen. The plants in pots 3 and 4, where the same amount of nitrate was used, do not appear to have been injured.

Excluding the high residual recovery from pots 25 and 26, the highest recovery, 9.07%, is with nitrate and alfalfa meal, and the lowest with nitrate and low-grade tankage. The residual recovery from nitrate in pots 3 and 4 is lower than the recovery from the organic materials, and, with one exception, lower than the recoveries from the combination of nitrate and organic materials. This is explained by the high recovery from these pots with the first crop.

When the sum of the recoveries for the two crops is taken, we find the nitrate standing highest, while the recoveries from the combination of organic matter and nitrate still stand higher than the recoveries from the organic materials alone.

Four points appear to be especially emphasized in this experiment.

1. The residual effects from the use of nitrate of soda are small, if the first crop develops normally, but are considerably increased where an excessive amount of the nitrate depressed the yield of dry matter in the first crop.

2. The residual effects from the use of organic nitrogenous materials are greater than the residual effects from nitrate of soda (with the exception noted in 1), but they are small when considered from the standpoint of the amount of nitrogen that apparently remains in the soil after the removal of the first crop.

3. The unaccounted-for nitrogen in the organic materials must have been dissipated, or it must remain in the soil in an unavailable form.

4. Nitrogen applied in the form of nitrate of soda and organic matter, half the nitrogen from one and half from the other, gives a higher yield of dry matter and a higher recovery of nitrogen than nitrogen which is all in the form of organic matter.

Further investigations are being carried out to determine, if possible, why less than 50% of the nitrogen of the organic matter is recovered.

EXPERIMENT No. 4. This experiment is a continuation of the work on the availability of mineral and organic nitrogenous materials. Two grams of nitrate of soda were used and quantities of the other materials to furnish an equivalent amount of nitrogen. The experiment was carried out in pots holding twenty pounds of pure white sand. To each pot there was added 4 grams acid phosphate, 2 grams potassium sulphate, 5 grams ground limestone, 0.5 gram magnesium sulphate, and 0.25 gram ferric sulphate. The moisture was maintained at about ten per cent. Buckwheat was grown to maturity during the summer of 1913 and grain and straw were harvested together. The special treatment given and data with reference to the yield of dry matter and yield of nitrogen are shown in Table IV.

Table IV—The Recovery of Nitrogen From Different Materials.

Pot No.	SPECIAL TREATMENT.	Nitrogen applied mgs.	Dry Matter gms.		Per cent. Nitrogen.	Total Nitrogen mgs.		Increase over Check.	Per cent. Nitrogen recovered.
			Per pot.	Average.		Per pot.	Average.		
1	No Nitrogen	...	0.9	1.30	1.415	12.74	19.65	......	......
2			0.9		1.407	12.66			
3			2.1		1.597	33.54			
4	2 gms. Na NO	308	13.7	14.03	1.787	244.82	260.10	240.45	78.07
5			15.1		1.863	281.31			
6			13.3		1.911	254.16			
7	1.460 gms. $(NH_4)\ SO_4$	308	13.5	13.43	1.178	159.03	198.64	178.99	58.11
8			13.5		1.654	223.29			
9			13.3		1.606	213.60			
10	0.918gms. $(NH_4)\ NO_3$	308	17.5	16.97	1.454	254.45	213.76	194.11	63.02
11			18.5		1.027	190.00			
12			14.9		1.321	196.83			
13	1.970 gms. $CaCN_2$	308	5.6	5.77	2.557	143.19	129.18	109.53	35.56
14			5.9		1.787	105.43			
15			5.8		2.395	138.91			
16	2.660 gms. $Ca\ (NO_3)_2$	308	18.7	17.93	1.027	192.05	240.70	221.05	71.77
17			16.6		1.625	269.75			
18			18.5		1.407	260.30			
19	2.430 gms. Dried Blood	308	14.1	13.73	1.321	186.26	183.34	163.39	53.15
20			14.0		1.264	176.96			
21			13.1		1.426	186.81			
22	8.084 gms. Green Rye, (Dried and Ground)	308	*21.3	7.20	*2.281	*485.85	99.07	79.42	25.79
23			7.2		1.280	92.16			
24			7.2		1.472	105.98			
25	11.323 gms. Alfalfa Meal	308	7.2	6.57	1.409	101.45	90.08	70.43	22.87
26			6.3		1.261	79.44			
27			6.2		1.441	89.34			

*Omit from average.

The yields of dry matter in the triplicate pots are, with two or three exceptions, in fair agreement. The highest average yield was obtained with calcium nitrate, and the next highest with ammonium nitrate. The lowest yield, which is less than one third the yield with calcium nitrate, is with calcium cyanamid. Here there were unmistakable evidences of toxic effects from the fertilizer. On August 1 it was noted that the leaves were small and stalks slender. It is not entirely clear why this material should thus prove toxic, but the low yield of dry matter and unusually high percentage of nitrogen, 2.557 in the case of pot 13, indicate an abnormal condition. Notwithstanding the stunted growth of the plants they took up nitrogen in larger quantities than plants showing normal growth. It is entirely possible that this abnormal storing up of nitrogen accounts for the failure of the plants to make normal development. Generally speaking the percentage of nitrogen in the crops from those pots that received organic nitrogenous materials is lower than it is in plants from pots that received mineral nitrogenous materials. This must be explained on the ground that these organic materials supply nitrogen in a moderately available form. It may be observed that these percentages are in most cases a little below the percentages in the check pots.

The highest recovery of nitrogen is 78.07 per cent. with nitrate of soda, and the next highest 71.77 with calcium nitrate. The recovery with ammonium nitrate although not so high as the recovery with sodium or calcium nitrate is higher than the recovery with ammonium sulphate. The recovery with calcium cyanamid is only about one half that with calcium nitrate, the low recovery here necessarially following the low yield. The recovery with dried blood is somewhat higher than is usually secured with this material. The recoveries with the ground green rye and alfalfa meal are about the same as are usually obtained with vegetable nitrogenous materials.

The results obtained here conform in the main with the results obtained in previous experiments. It may be pointed out that the toxic effect observed in connection with calcium cyanamid would have been lessened and in all probability entirely obviated had the plants been grown in soil rather than sand, for the reason that soils possess a greater power of absorbing toxic materials and making them harmless than does sand.

EXPERIMENT NO. 5. In this experiment materials representing green manure crops are used alone, with nitrate of soda, and with nitrate of soda and ground limestone, the object being to determine whether or not the ground limestone aids in the decomposition of the organic matter and the production of available nitrogen. Pots holding nine pounds of loam soil were used. As a general treatment, all pots received 4 grams acid phosphate, 2 grams potassium sulphate, 2 grams ground limestone, 0.5 gram magnesium sulphate and .25 gram ferric sulphate. The moisture was maintained at about 15 per cent. The 2 grams of ground limestone, applied as a part of the general treatment, was intended to establish average conditions for growth in all pots, while to certain of the pots 10 grams additional ground limestone were applied in order that in these pots there might be an excess of this material. The organic materials were chopped up, ground and mixed in the soil. Definite weights of these were applied without taking into consideration the amount of nitrogen thus furnished. Buckwheat was grown in these pots during the summer of 1913, and this was harvested without separating grain and straw.

The special treatment given, together with the yield of dry matter, percentage of nitrogen and the increase of nitrogen over the check, are shown in Table V.

Table V—The influence of Ground Limestone on the Decomposition of Green Manure.

Pot No.	SPECIAL TREATMENT.	Nitrogen applied mgs.	Dry matter grms.	Per cent. nitrogen.	Average nitrogen mgs.	Increase over checks mgs.	Per cent. nitrogen recovered.
1 2	No Nitrogen	....	6.0 5.7	1.105 1.347	71.54	Av. checks 81.22	......
3 4	2 gms. $Na NO_3$	308	15.0 14.7	1.948 2.054	297.07	215.85	70.08
5 6	30 ms. Green Alfalfa	....	15.4 13.7	1.463 1.521	216.84	135.62	......
7 8	30 gms. Green Alfalfa + 10 gms. $CaCO_3$	....	16.7 15.0	1.424 1.560	235.91	154.69	......
9 10	2 gms. $NaNO_3$ + 30 gms. Green Alfalfa	....	11.2 14.1	2.277 2.306	290.09	208.87	......
11 12	2 gms. $NaNO_3$ + { 30 gms. Green Alfalfa 10 gms. $CaCO_3$	....	16.6 19.1	2.422 2.355	425.93	344.71	......
13 14	2 gms. $NaNO_3$	308	14.0 12.0	1.996 2.074	264.16	182.94	59.40
15 16	30 gms. Green Timothy	....	7.7 10.5	1.326 1.298	119.20	37.98	......
17 18	30 gms. Green Timothy + 10 gms. $CaCO_3$	....	10.0 9.9	1.260 1.260	125.37	44.15	......
19 20	2 gms. $NaNO_3$ + 30 gms. Green Timothy	....	13.2 13.5	2.045 1.744	252.69	171.47	......
21 22	2 gms. $NaNO_3$ + { 30 gms. Green Timothy 10 gms. $CaCO_3$	....	13.3 15.5	2.238 2.141	314.76	233.54	......
23 24	2 gms. $NaNO_3$	308	15.0 13.0	2.132 1.986	288.99	207.77	67.46
25 26	30 gms. Green Oats and Peas	....	11.6 7.3	1.376 1.783	144.89	63.67	......
27 28	30 gms. Green Oats and Peas + 10 gms. $CaCO_3$	....	14.7 13.0	1.269 1.337	180.18	98.96	......
29 30	2 gms. $NaNO_3$ + 30 gms. Green Oats and Peas	....	14.1 12.2	2.326 2.306	304.65	223.43	......
31 32	2 gms. $NaNO_3$ + { 30 gms. Gr. oats & peas. 10 gms. $CaCO_3$	....	16.2 17.8	2.200 2.219	375.69	294.47	......
33 34	No Nitrogen	....	7.8 7.9	1.163 1.153	90.90	Av. checks 81.22	......

With two or three exceptions, the duplicate weights agree nicely. In every instance the average yield of dry matter is higher with the ground limestone than without, and this is true whether it is used with the green manure alone, or with the green manure and nitrate of soda. The highest average yield, 17 grams, occurs in pots 31 and 32 where the ground limestone is used with nitrate and green oats and peas, while the lowest yield, 9.1 grams, occurs with green timothy alone.

The percentage of nitrogen varies from a little more than 1 per cent. for the checks to nearly 2½ per cent. where limestone is used in connection with nitrate and green alfalfa. The percentage of nitrogen is invariably higher where nitrate is used in connection with the green crop, both limed and unlimed, or the green crop in connection with limestone.

The highest average amount of nitrogen recovered is 425.93 grams where limestone is used with nitrate and green alfalfa; the smallest amount, excluding the checks, is 119.2 grams with green timothy alone. Where limestone is used with green manures, the increase over the check is invariably greater than where the green manure is used alone. Also, where limestone is used in connection with nitrate and green manure, the increase is invariably greater than where the nitrate and green manure are used without limestone. Thus, the average increase for pots 9 and 10, with 2 grams of nitrate and 30 grams of alfalfa, is 208.87 grams, while with these materials plus 10 grams of limestone, it is 344.71 grams. The increase with 2 grams of nitrate and 30 grams of green timothy is 171.47 grams, and, with the nitrate and green timothy plus 10 grams of limestone, it is 233.54 grams. The increase with 2 grams of nitrate and 30 grams of green oats and peas is 223.43 grams, and, with the nitrate and green oats and peas plus the 10 grams of limestone, it is 294.47 grams. It is, therefore, quite evident that the limestone did aid in the decomposition of the organic matter and in making the nitrogen more available. It is quite clear, likewise, that the nitrogen of leguminous crops becomes more quickly available than the nitrogen of the non-leguminous crops.

Farmers have sometimes complained that the turning under of green crops "sours" or "deadens" the soil. Undoubtedly, such conditions have been observed, and it is quite possible that this deadening of the soil is due to fermentation and slow decomposition of green crops that have been turned under, and that a liberal application of ground limestone, made before the green crops are turned under, would largely obviate this difficulty. The results of this experiment point to such treatment as the solution for this difficulty.

EXPERIMENT No. 6. The object of this experiment was very much the same as that of No. 4, that is to determine whether the presence of green vegetable matter in the soil interferes with the germination of seed and the growth and development of plants, and further to determine the effect of ground limestone on the decomposition of such green materials and the formation of available nitrogen.

A mixture consisting of nine pounds of sand and nine pounds of loam soil was used. As a general treatment, all pots received 2 grams nitrate of soda, 4 grams acid phosphate and 2 grams potassium sulphate, all of which were thoroughly mixed with the soil. 10 per cent. of water was allowed for the sand and 15 per cent. for the soil. The green rye was chopped up and placed in a layer about four inches beneath the surface of the mixture to represent a green crop turned under. Where ground limestone was used, this was sprinkled over the green rye. (It may be noted here that the results would probably have been more satisfactory had the green rye and ground limestone been mixed with the top three or four inches of the soil instead of being placed in a compact layer.)

Barley was grown during the winter of 1913-14, and harvested at maturity. The dry weights were recorded and nitrogen determinations made in the usual way.

In all cases the pots receiving the green rye, and green rye and limestone, show an increased yield over the checks. The yield with the green rye and limestone is, however, in most cases about the same as the yield with the green rye alone. The highest average yield is 35.2 grams with limestone and 100 grams of green rye. The large amount of nitrogen furnished by this quantity of green rye gave a rank growth of plant with slight development of grain. On May the 5th it was noted that plants in pots 22 to 27 were greener than the others and that the heads were little more than chaff and beards.

The average percentage of nitrogen is in all cases higher where green rye is used than it is for the checks, but when ground limestone is applied with the green rye, there is not any decided increase in percentage of nitrogen over those with the green rye alone. Two out of the three that received limetone with the green rye show an increase over the check greater than the increase shown by those that received green rye alone.

While the results secured in this experiment are not so positive as those of Experiment No. 4, there is still evidence that the ground limestone has had a beneficial influence on the decomposition of the organic matter and in making the nitrogen of this available. There appeared to be no essential difference in germination between pots receiving the green rye and the check pots.

THE FORMATION OF CARBON DIOXIDE AND NITRATES IN THE PRESENCE OF LARGE AMOUNTS OF CARBOHYDRATES.

Experiments conducted at this Station[1] have shown definitely that large applications of carbohydrates depress the yield of dry matter and the amount of nitrogen recovered.

Investigators abroad have likewise called attention to this fact, and farmers have occasionally noted that unusually large applications of manure seemed to depress the yield. Explanations have been suggested, but, so far as we know, no positive cause has been assigned. In endeavoring to explain this, it occurred to one of us that the amount of carbon dioxide formed might in some way throw light on this question. It was decided, therefore, to collect and determine the carbon dioxide evolved from a given weight of soil under uniform conditions.

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[1] Report of Soil Chemist and Bacteriologist for 1911, pp. 193-312, and report for 1912, pp. 213-233.

To accomplish this 100 grams of moderately acid loam soil were placed in glass tumblers under bell jars, and these bell jars connected on the one side with two bottles containing strong potassium hydroxide and on the other with an Erlenmeyer flask containing a measured quantity of standard barium hydroxide solution. The apparatus was made air-tight and connected with a Chapman filter pump, so that air, freed from carbon dioxide, could be drawn through, thus bringing the carbon dioxide evolved from the soil into the barium hydroxide with the formation of barium carbonate. Before setting up the apparatus, the soil was brought to the optimum moisture condition and one gram of finely ground limestone was thoroughly mixed with each portion. To two of the portions of soil three grams of dextrose were added and to the other two no dextrose was added. The carbon dioxide was determined by titrating the excess of barium hydroxide against standard oxalic acid.

The experiment was continued for 39 days, titrations being made from time to time as the barium hydroxide approached neutrality. For the first two days the evolution of carbon dioxide was very nearly the same from the four portions of soil, but, after the second day, it was evolved very slowly from the two portions which received no dextrose. From the two portions which received dextrose there was a rather rapid and fairly constant evolution of carbon dioxide from the third to the twenty-second day, when the flow was somewhat reduced, though gas had not ceased coming off when the experiment was, for the lack of time, discontinued.

On disconnecting the apparatus the nitrates were determined in the four portions of soil by the colorimetric method.

Nearly ten times as much carbon dioxide was evolved from the portions of soil that received dextrose as from the checks. On the other hand, there was approximately 122 times as much NO_3 in the non-dextrose portions as in the dextrose portions.

The work must be repeated with different amounts and different forms of carbohydrates, and with different types of soil, before conclusive results are had, but the initial results are significant.

Two explanations suggest themselves: either the dextrose in some way inhibits nitrification, or rapid denitrification takes place in the presence of dextrose; or organisms which are aided in their development and multiplication by the presence of the dextrose, build the nitrates into their bodies, making them, in this case, unavailable for detection as nitrates, and in the case of vegetation experiments, making them unavailable for the plants.

The possibility of direct injury to the plants from carbon dioxide evolved seems remote for the reason that such injury does not appear to have been noted in soils very rich in organic matter where large quantities of carbon dioxide would necessarily be evolved, and, further, because, in the pot experiments cited above, the plants did not revive after weeks of growth when the carbon dioxide should have been largely dissipated.

Further work along this line is being conducted.

THE CONTINUOUS GROWING OF WHEAT AND RYE—1914.

The plan of this experiment was fully described in the Annual Report for 1912.* The results for the first five years were given there in detail and a further account appears in the Annual Report for 1913. For convenience, the general plan may be briefly restated.

Plan of Experiment.

The experiment is being conducted on four one-twentieth acre plots, designated as numbers 68, 69, 70, and 71. The soil is a gravelly loam fairly uniform in quality. Previous to starting this experiment the land had been used for general farming, but had not been heavily manured and had not been limed for more than twenty years. When the experiment was begun, all plots were limed at the rate of 2,000 pounds of ground limestone per acre. The plots also receive annually an application of minerals (acid phosphate and muriate of potash) at the rate of 400 pounds of acid phosphate and 200 pounds of muriate of potash per acre. No nitrogenous fertilizers are used. Tests made of samples of soils collected from these plots in the spring of 1913 show a lime requirement of four to six hundred pounds of lime (CaO) per two million pounds of soil. In the fall of 1913, before seeding to wheat and rye, they received limestone at the rate of 4,000 pounds per acre.

The arrangement of plots, with the treatment given, is as follows:

Plot 68, Rye alone	Minerals
Plot 69, Wheat alone	Minerals
Plot 70, Rye followed each year with Cow Peas (or Soy Beans) as green manure	Minerals
Plot 71, Wheat followed each year with Cow Peas (or Soy Beans) as green manure	Minerals

Each year the stubble is disked on Plots 70 and 71 soon after harvesting the crop, and soy beans are drilled in. Plots 68 and 69 remain in stubble. About two or three weeks before seeding to wheat and rye, the green manure crop on Plots 70 and 71 is turned under and Plots 68 and 69 are also prepared for seeding. On account of cow pea wilt in the soil, Ito San soy beans were substituted for the cow peas on Plots 70 and 71 in the fall of 1913. At the time of plowing under the soy beans, September 8, it was noted that they were about 15 inches high, and that there was an even stand and fair inoculation. On September 24 the plots were further prepared, mineral fertilizers applied and seeded to rye and wheat in accordance with the plan.

Crop for 1914.

As was the case last year so again this year the yields of both rye and wheat were unduly low. However, it is to be noted that the yield on the legume plots is decidedly in excess of that on the non-legume plots.

The yield of rye grain is nearly one-fourth more, and the yield of wheat grain more than doubled. The yield of wheat straw on the legume plots is also more than double that on the non-legume plots.

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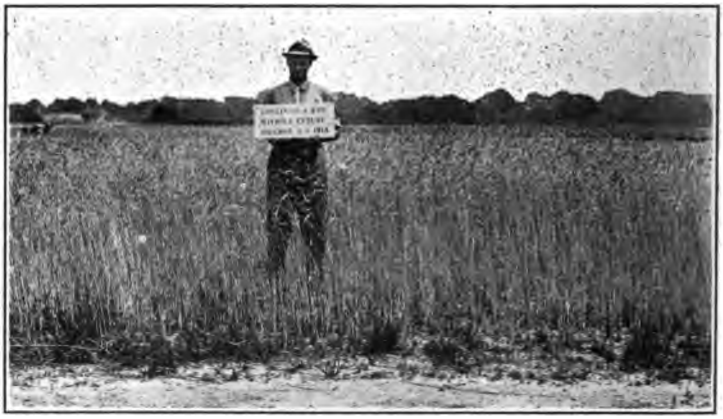
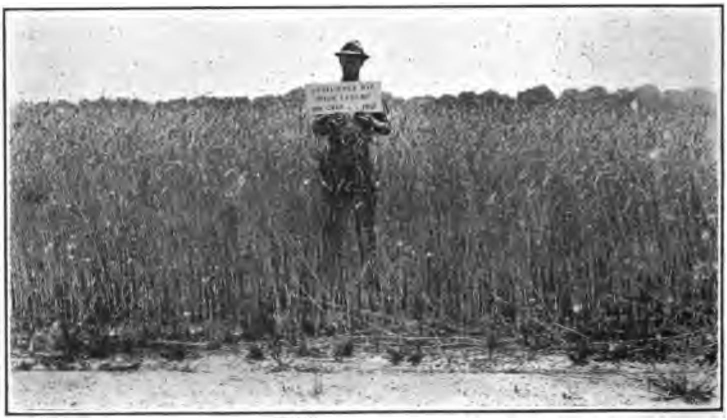
*Report Soil Chemist and Bacteriologist, N. J. Agri. College Expt. Sta. 1912, p. 261.

PLATE I.



PLOT No. 68.—Continuous Rye. No. Nitrogen Supplied.



PLOT No. 70.—Continuous Rye. Nitrogen Supplied by Leguminous Crop Grown Each Year After Harvesting the Rye.

The percentage of nitrogen is higher in the rye, both grain and straw, from the legume plots. than from the non-legume plots. In the case of the wheat it is practically the same in both. While the yields are not what they should be it is clear that the leguminous crops are responsible for substantial gains in grain and straw and in amount of nitrogen recovered. The nitrogen recovered with rye alone is at the rate of 19.44 lbs. per acre, and with rye followed by the legume it is at the rate of 26.56 lbs. per acre. With the wheat the nitrogen recovered from the legume plot is more than double that from the non-legume plot.

With thicker seeding of the soy beans and by selecting a variety with a more luxuriant growth, as for example the Swan, it will unquestionably be possible to materially increase the yields of grain and straw and, therefore, the amount of nitrogen accumulated.

Table I—Rye and Wheat with and without Legumes, 1914.
(1-20 Acre Plots)

Plot No.	CROP.	GRAIN PER PLOT.			STRAW PER PLOT.			PER ACRE.		
		Dry Matter lbs.	Per cent. nitro'n	Nitrogen lbs.	Dry matter lbs.	Per cent. nitro'n	Nitrogen lbs.	Grain bushels	Straw lbs.	Nitrogen lbs.
68	Rye alone.............	46.0	1.466	.674	92.0	.324	.298	16.43	1840	19.44
69	Wheat alone..........	18.0	1.972	.355	36.0	.578	.208	6.00	720	11.26
70	Rye followed by Soy Beans..............	54.0	1.542	.833	138.0	.359	.495	19.29	2760	26.56
71	Wheat followed by Soy Beans..............	40.0	1.963	.785	78.0	.570	.445	13.33	1560	24.60

THE INFLUENCE OF BACTERIA IN MANURE ON THE DECOMPOSITION OF GREEN MANURE. (LEGUME AND NON-LEGUME.

An account of the first five years of this work was given in the report for 1912, and an account of the work for 1913 in the report for that year. The object of the experiment is to study the bacterial influence of cow manure on the decomposition of green manures. The quantities of manure are purposely kept small in order that the influence of the fertilizing constituents in the manure may be reduced to a minimum. The experiment also contemplates a comparison of legumes with non-legumes in continuous corn growing.

For convenience a brief statement of the plan is included here.

Plan of the Experiment.

"The experiment is conducted on one-twentieth acre plots, on land that is largely a gravelly loam, varying from sandy to clayey phases, although apparently the differences are not great. The soil is not what would be called a fertile soil, and is without doubt deficient in nitrogen, this being the chief limiting factor. At the beginning of the experiment ground limestone, at the rate of one ton per acre, was applied to all the plots by means of a fertilizer drill, and each plot also received fifteen pounds of acid phosphate, five pounds of potassium chloride, and ten pounds of dried fish. The special treatment is as follows:

Plot 49, corn followed by crimson clover as green manure, no cow manure.
Plot 50, corn followed by crimson clover as green manure, + 50 lbs. manure.
Plot 51, corn followed by crimson clover as green manure + 100 lbs. manure.
Plot 52, corn followed by crimson clover as green manure + 200 lbs. manure.
Plot 53, corn followed by rye as green manure, no cow manure.
Plot 54, corn followed by rye as green manure, + 50 lbs. cow manure.
Plot 55, corn followed by rye as green manure, + 100 lbs. cow manure.
Plot 56, corn followed by rye as green manure, + 200 lbs. cow manure.

The manure is preferably that which has been well rotted, and is broadcasted over the green manure before plowing under."

Crop of 1914.

The crimson clover and vetch which were seeded in the corn, Plots 49-52, in the fall of 1913 did not make a satisfactory growth. It is very hard for these crops to get a start while the corn is growing, especially if the weather is dry.

The following notes were made May 11, 1914:

Plot 49, Crimson Clover in scattered clumps, no vetch; poorest of crimson clover.
Plot 50, Clover scattered, better than plot 49. No vetch.
Plot 51, Better than plot 50. No vetch.
Plot 52, Same as plot 51.

On the same date the following notes were made with reference to the rye:

Plot 53, Rye knee deep; poorest of rye plots.
Plot 54, Better than 53.
Plot 55, Same as plot 54.
Plot 56, Rye not so good as on 54. Better than 53.

As in previous years the cow manure was spread over the green manure crops and all plowed under about the middle of May. The plots received fifteen pounds of acid phosphate and five pounds of muriate of potash and were prepared for planting. On May 16 they were planted to Reed's Yellow Dent Corn, which received the usual cultivation. On August 4 cover crops were seeded in the corn as follows: Plots 49-52 crimson clover, vetch and soy beans; and Plots 53-56 rye. These, however, made very poor growth on account of the unusually long period of dry weather. The soy beans were a complete failure. Plots 49-52 were inoculated for soy beans and vetch. On September 25 the corn was harvested and after being partially dried one-twentieth of the entire weight from each plot was taken as a sample and after further drying was prepared for analysis in the usual way. The yield of dry matter, percentage of nitrogen and other data are shown in Table II.

Table II—Corn 1914.
(Calculated to Acre basis)

Number.	TREATMENT.	GRAIN.		STALKS.		COBS.		Total nitrogen lbs.	INCREASE OVER CHECK.		
		Dry matter bu.	Per cent nitrogen.	Dry matter lbs.	Per cent nitrogen.	Dry matter lbs.	Per cent nitrogen.		Dry matter grain bu.	Dry matter stover lbs.	Total nitrogen lbs.
					Legume Section.						
49	No manure.	30.71	1.273	2800	0.698	280	0.401	42.563	......	......	......
50	50 lbs. cow manure .	38.57	1.421	3400	0.602	360	0.401	52.604	7.86	680	10.041
51	100 lbs. cow manure	36.43	1.369	3560	0.602	360	0.392	50.770	5.72	840	8.207
52	200 lbs. cow manure	36.79	1.299	3120	0.715	320	0.366	50.238	6.08	360	7.675
					Non-Legume Section.						
53	No manure.	20.00	1.256	2720	0.558	200	0.436	30.117	......	......	......
54	50 lbs. cow manure .	29.64	1.378	3040	0.576	300	0.419	41.542	9.64	420	11.425
55	100 lbs. cow manure	34.29	1.317	3200	0.576	320	0.419	45.059	14.29	600	14.942
56	200 lbs. cow manure	28.57	1.360	2600	0.654	280	0.401	39.887	8.57	....	9.770

The results are calculated to the acre basis, and the grain is reported in bushels, while the stover and nitrogen are reported in pounds.

The Influence of the Manure.

An examination of the table shows that with but one exception the yield of dry matter—grain, straw and cobs—is higher on the plots that receive manure than on the check plots. As pointed out in previous reports this increase cannot be attributed to the fertilizing constituents in the manure for the reason that it frequently happens that the increase is greater on the plots that receive 50 or 100 pounds of manure than on those that receive 200 pounds. Likewise the percentage of nitrogen in the grain is higher in all plots that receive manure than in the check plots. This, however, does not hold true for the stalks and cobs, for with these the nitrogen runs fairly constant.

The total nitrogen recovered in the crop is invariably higher on the manured than on the unmanured plots, but here again larger yields are noted with 50 and 100 pounds per plot than with 200 pounds per plot.

The Legume and Non-legume Sections Compared.

As we should expect, the yields on the legume section are always higher than on the non-legume section and in the grain the percentage of nitrogen is also higher. This is not always true of the stalks and cobs, but the total yield of nitrogen is in every case higher on the legume than on the non-legume plots.

On the contrary the increase over the check, both grain and nitrogen is greater for the non-legume plots than for the legume plots. This is unquestionably due to the fact that the check plot in the legume section is able to utilize atmospheric nitrogen and thus approach more nearly to the nitrogen yield of the other plots in that section, an advantage which the check plot in the non-legume section does not have.

From the data here reported there seems to be good reason for believing that the bacteria conveyed in small quantities of manure do have a beneficial effect in the decomposition of the green manure crops. When the green manure crop is a legume, the additional nitrogen thus secured tends to obscure the effects of the manure. Certainly the legume is more effective in increasing the yield and also in maintaining the nitrogen supply of the soil than the non-legume, and there is good ground for believing that the nitrogen in the former is more available than in the latter.

THE INFLUENCE OF THE MECHANICAL COMPOSITION OF THE SOIL ON THE AVAILABILITY OF NITRATE OF SODA AND DRIED BLOOD.

This is a continuation of work that was begun in the spring of 1911, and the results for 1911, 1912 and 1913 have already been published.* For convenience, a diagram showing the plan of the experiment, together with a brief description, as presented in previous reports, are herewith submitted.

"The soil used was the typical red shale that had not been under cultivation. This was screened to remove stones, and was then mixed with sand in varying proportions as indicated in the accompanying diagram. The soil was then placed in cylinders of the type that has been in use at this Station for a number of years,† and to each cylinder there were added 38 gms. of precipitated chalk, 20 gms. acid phosphate, 5 gms. potassium chloride, 5 gms. potassium sulphate and 2 gms. magnesium carbonate. As originally planned the five-year rotation included corn, oats, wheat and timothy. Later it was decided to substitute barley for oats, consequently the 1912 crop was barley with buckwheat as a residual crop. Each group of six cylinders is set off in three pairs, and each of the three pairs of a group receives a different fertilizer treatment, which treatment, however, is common to all groups. Thus the first and second cylinders of any group receive no fertilizer, the third and fourth receive ten gms. of nitrate of soda and the fifth and sixth dried blood equivalent to ten gms. of nitrate of soda."

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*Reports of Soil Chemist and Bacteriologist, New Jersey Agricultural College Experiment Station, 1911, 1912 and 1913.

†Bul. 221, N. J. Expt. Sta.

Plan of Experiment.

Series	Arrangement of Cylinders.	Soil.	Treatment.
A.....	① ② ③ ④ ⑤ ⑥	Shale soil..	1, 2, nothing. 3, 4, 10 gms. nitrate soda. 5, 6, 13.39 gms. dried blood.
B.....	① ② ③ ④ ⑤ ⑥	10% sand....	"
C......	① ② ③ ④ ⑤ ⑥	20% "	"
D.	① ② ③ ④ ⑤ ⑥	30% "	"
E.....	① ② ③ ④ ⑤ ⑥	40% "	"
F......	① ② ③ ④ ⑤ ⑥	50% "	"
G.....	① ② ③ ④ ⑤ ⑥	70% "	"
H.....	① ② ③ ④ ⑤ ⑥	80% "	"
I......	① ② ③ ④ ⑤ ⑥	90% "	"
J......	① ② ③ ④ ⑤ ⑥	100% "	"

First Crop—Barley, 1914.

The cylinders remained bare during the winter of 1913-14 and were prepared and seeded to barley early in May.

The fertilizer treatment was the same as in previous years, and 38 grams of non-magnesian limestone and 2 grams of magnesium carbonate were applied to each cylinder. The barley made an average growth and was harvested about the last of July, dried, weighed and samples prepared for analysis in the usual way. The dry weights and other analytical data are given in Table III.

Table III—Barley—1914.

Series		Nitrogen applied gms.	Dry matter. grams. Per cylinder.	Dry matter. grams. Average.	Per cent nitrogen.	Nitrogen grams. Per cylinder.	Nitrogen grams. Average.	Nitrogen increase over check, grams.	Per cent nitrogen recovered.	Relative availability.
A...	1	Nothing	58.5	50.25	1.104	.646	.574	....	....	....
	2		42.0		1.192	.501				
	3	1.54	70.5	94.50	1.586	1.118	1.338	.764	49.61	100.00
	4		118.5		1.314	1.557				
	5	1.54	65.0	65.10	1.472	.957	.905	.331	21.49	43.3
	6		65.2		1.306	.852				
B...	1	Nothing	55.5	54.75	1.087	.603	.619	....	....	....
	2		54.0		1.174	.634				
	3	1.54	107.0	100.00	1.481	1.585	1.510	.891	57.86	100.00
	4		93.0		1.542	1.434				
	5	1.54	106.2	100.60	1.332	1.415	1.345	.726	47.14	81.5
	6		95.0		1.341	1.274				
C...	1	Nothing	42.0	42.25	1.165	.489	.492	....	....	....
	2		42.5		1.165	.495				
	3	1.54	110.5	93.10	1.411	1.559	1.297	.805	52.28	100.00
	4		75.7		1.367	1.035				
	5	1.54	86.3	83.40	1.200	1.036	1.019	.527	34.22	65.45
	6		80.5		1.244	1.001				
D...	1	Nothing	37.0	37.75	1.165	.431	.437	....	....	....
	2		38.5		1.148	.442				
	3	1.54	114.4	109.65	1.279	1.463	1.430	.993	64.48	100.00
	4		104.9		1.332	1.397				
	5	1.54	92.0	82.45	1.323	1.217	1.100	.663	43.05	66.76
	6		72.9		1.349	.983				
E...	1	Nothing	40.2	38.10	1.078	.433	.409	....	....	....
	2		36.0		1.069	.385				
	3	1.54	115.0	108.00	1.271	1.462	1.430	1.021	66.30	100.00
	4		101.0		1.384	1.398				
	5	1.54	85.0	81.85	1.157	0.983	1.012	.603	39.16	59.07
	6		78.7		1.323	1.041				
F...	1	Nothing	43.0	42.25	1.052	.452	.448	....	....	....
	2		41.5		1.069	.444				
	3	1.54	112.2	111.35	1.218	1.367	1.371	.923	59.94	100.00
	4		110.5		1.244	1.375				
	5	1.54	88.7	91.45	1.252	1.111	1.146	.698	45.32	75.63
	6		94.2		1.252	1.181				
G...	1	Nothing	34.4	33.05	1.016	.350	.328	....	....	....
	2		31.7		.964	.306				
	3	1.54	120.0	121.25	1.139	1.367	1.424	1.096	71.17	100.00
	4		122.5		1.209	1.481				
	5	1.54	99.5	103.25	1.174	1.168	1.175	.847	55.00	77.28
	6		107.0		1.104	1.182				
H...	1	Nothing	26.0	28.15	.990	.257	.284	....	....	....
	2		30.3		1.025	.311				
	3	1.54	113.2	115.60	1.087	1.230	1.319	1.035	67.21	100.00
	4		118.0		1.192	1.407				
	5	1.54	106.5	100.25	1.148	1.223	1.151	.867	56.30	83.9
	6		94.0		1.148	1.079				
I....	1	Nothing	16.5	18.45	1.192	.197	.213	....	....	....
	2		20.4		1.122	.229				
	3	1.54	102.0	108.20	1.130	1.153	1.193	.980	63.64	100.00
	4		114.4		1.078	1.233				
	5	1.54	86.7	86.95	1.192	1.033	1.021	.808	52.47	82.5
	6		87.2		1.157	1.009				
J....	1	Nothing	8.0	8.75	1.157	.093	.109	....	....	....
	2		9.5		1.314	.125				
	3	1.54	98.5	79.15	1.130	1.113	1.020	.811	52.67	100.00
	4		59.8		1.551	.927				
	5	1.54	73.5	67.60	1.113	.818	.801	.692	44.93	85.3
	6		61.7		1.271	.784				

With the exception of Nos. 3 and 4 in series "A," "C" and "J," the duplicates are in very fair agreement. The highest average yield is 121.25 grams with nitrate of soda in series "G," where the mixture is 70 per cent. sand, and the next highest is 115.6 grams with nitrate of soda in series "H," 80 per cent. sand. However, cylinder No. 4 in series "A," pure shale, gave a yield of 118.5 grams. With one exception only, that of series "B," nitrate gave a higher yield than dried blood. In previous years we have found a higher yield of dry matter with dried blood than with nitrate in cylinders having 80 to 100 per cent. of sand, but it is not so with this crop. The average yield for the check cylinders is invariably lower than for either the dried blood or nitrate treatment.

In series "A," "B" and "C," the percentage of nitrogen is higher for those cylinders that receive nitrate than for those that receive dried blood. For the remaining series the percentage of nitrogen for the two treatments runs very nearly the same. With one exception only, the average percentage of nitrogen for the check cylinders is less than the average for either dried blood or the nitrate treatment. The percentages of nitrogen are, on an average, higher for series "A," "B," "C" and "D" than for the remaining series. Whether this is due to the heavier soil, that is, soil containing higher percentages of shale, or whether it is accidental, is not clear. It does not appear to have been so in previous years. The highest yield of nitrogen for a single cylinder, 1.585 grams, occurs with nitrate of soda in series "B," which is 10 per cent. sand, and it is also the nitrate treatment of this series that gives the highest average. The percentage of nitrogen recovered is in every case higher with nitrate of soda than with dried blood. It is of interest to note that the highest recovery is in series "G," with 70 per cent. of sand, and the next highest in series "H," with 80 per cent. of sand. These recoveries, 71.17 and 67.21 respectively, are a close approach to recoveries that have been secured in many of the pot experiments conducted at this Station. The highest recoveries with dried blood are likewise in these same series, and these are above the recoveries usually obtained in pot experiments. The lowest recovery for both nitrate and dried blood occurs in series "A." This may no doubt be attributed to poor physical condition, due largely to a deficiency of organic matter.

The average of all series for nitrate of soda is 60.516 and for dried blood 43.918. These figures agree quite closely with the ten-year averages obtained in the cylinder experiments* with loam soil.

If we place the average availability for nitrate at 100, then the average availability for dried blood will be 72.07. It may be pointed out that, on the basis of 100 for nitrate of soda, the average availability for dried blood in series "H," "I" and "J" is 83.9, while, on the same basis, the average availability for series "A" to "G," inclusive, is 67. This again points to a higher availabilty for dried blood than for nitrate in sand or very sandy soil.

In no one of the combinations of sand and soil, or pure soil and sand, does the dried blood show an availability equal to that of the nitrate of

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*Bulletin 221 New Jersey Agricultural College Experiment Station.

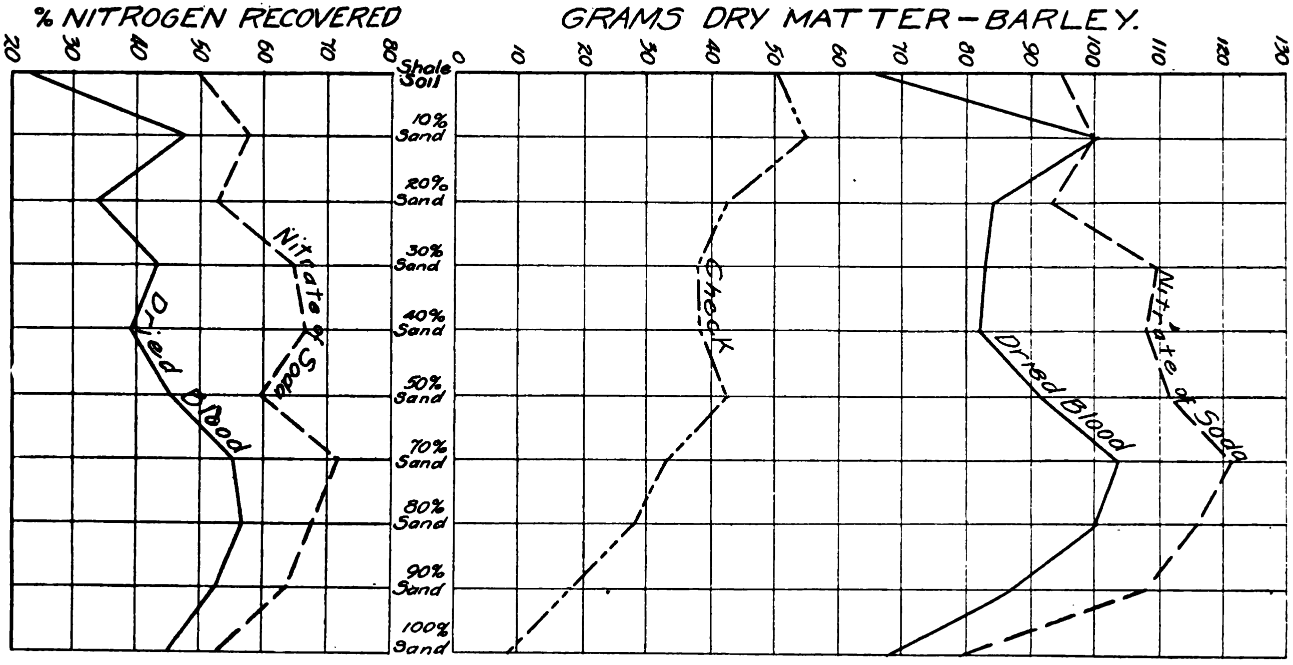

FIGURE 1.—Weight of Dry Matter and Per Cent. Nitrogen in First Crop—Barley.

soda. When this is true, there seems little excuse for the farmer to pay more for nitrogen in organic materials than in the form of nitrate.

The relative yields of dry matter and percentage of nitrogen recovered for the different treatments are indicated by curves in Fig. 1.

Residual Crop of Buckwheat, 1914.

Following the barley, the cylinders were prepared and seeded to buckwheat without additional fertilizer, with the intention of utilizing, to the fullest extent possible, the nirogen that was applied to the first crop. The buckwheat was harvested October 1st, dried and weighed and samples prepared for analysis. The results are given in Table IV.

Table IV—Residual Crop of Buckwheat, and Summary for both Crops, 1914.

	RESIDUAL CROP.							BOTH CROPS.				
	Dry matter grams,											
Series No.	Per cylinder.	Average.	Per cent. nitrogen.	Nitrogen per cylinder.	Grams, average.	N trogen increase over check gms.	Residual nitrogen recovered. Per cent.	Nitrogen increase over check grams.	Per cent. nitrogen recovered.	Relative availability.	Total nitrogen grams.	Total dry matter grams.
A. 1	21.5	28.00	1.612	.347	.447	....	......	......	......	......	1.021	78.25
2	34.5		1.586	.547								
3	24.0	24.00	1.937	.465	.465	.018	1.17	.782	50.78	100	1.803	118.50
4	*2.5		2.015	*.050								
5	34.7	33.95	1.901	.660	668	.221	14.35	.552	35.84	70.6	1.573	99.05
6	33.2		2.033	.675								
B. 1	32.0	26.00	1.612	.516	.441	....	......	......	......	......	1.060	80.75
2	20.0		1.823	.365								
3	15.0	18.85	1.980	.297	.385	....	......	.891	57.86	100	1.895	118.85
4	22.7		2.085	.473								
5	25.0	25.00	1.875	.469	.492	.051	3.31	.777	50.45	87.2	1.837	125.60
6	25.0		2.059	.515								
C. 1	8.5	11.75	1.963	.167	.209	....	......	....	......	......	.701	54.00
2	15.0		1.674	.251								
3	23.0	27.50	1.717	.395	.513	.304	19.74	1.109	72.02	100	1.810	120.60
4	32.0		1.972	.631								
5	30.7	33.60	1.910	.586	.586	.377	24.48	.904	58.70	81.5	1.605	117.00
6	36.5		1.604	.585								
D. 1	20.5	19.75	1.525	.313	.308	....	......	......	......	......	.745	57.50
2	19.0		1.595	.303								
3	24.0	24.00	1.717	.412	.405	.097	6.30	1.090	70.78	100	1.835	133.65
4	24.0		1.656	.397								
5	13.5	21.25	2.234	.302	.392	084	5.45	.747	48.50	68.5	1.492	103.70
6	29.0		1.658	.481								
E. 1	20.7	22.60	1.584	.328	.362	....	......	......	......	......	.771	60.70
2	24.5		1.612	.395								
3	21.5	24.75	1.674	.360	.405	.043	2.79	1.064	69.09	100	1.835	132.75
4	28.0		1.604	.449								
5	34.3	33.90	1.551	.532	.561	.199	12.92	.802	52.08	75.4	1.573	115.75
6	33.5		1.761	.590								
F. 1	30.5	28.10	1.384	.422	.402	....	......	......	......	......	.850	70.35
2	25.7		1.481	.381								
3	28.5	33.35	1.639	.467	.518	.116	7.53	1.039	67.47	100	1.889	144.70
4	38.2		1.490	.569								
5	45.8	34.80	1.568	.718	.550	.148	9.61	.846	54.93	81.4	1.696	126.25
6	23.8		1.604	.382								
G. 1	19.0	20.50	1.384	.263	.275	....	......	......	......	......	.603	53.55
2	22.0		1.304	.287								
3	18.5	18.85	1.455	.269	.271	....	......	1.096	71.17	100	1.695	140.10
4	19.2		1.420	.273								
5	27.0	27.25	1.455	.393	.393	.118	7.66	.965	62.66	88.0	1.568	130.50
6	27.5		1.428	.393								
H. 1	22.7	21.35	1.384	.314	.297	....	......	......	......	......	.581	49.50
2	20.0		1.393	.279								
3	15.0	19.50	1.472	.221	.292	....	......	1.035	67.21	100	1.611	135.10
4	24.0		1.507	.362								
5	30.0	29.10	1.358	.407	.484	.187	12.14	1.054	68.44	101.8	1.635	129.35
6	28.2		1.490	.561								
I. 1	16.0	15.75	1.332	.213	.228	....	......	......	......	......	.441	34.20
2	15.5		1.568	.243								
3	15.5	15.50	1.507	.234	.243	.015	0.97	.995	64.61	100	1.436	123.70
4	15.5		1.621	.251								
5	25.0	24.00	1.744	.436	.389	.161	10.46	.969	62.93	97.4	1.410	110.95
6	23.0		1.481	.341								
J. 1	4.5	6.5	1.910	.086	.116	....	......	......	......	......	.225	15.25
2	8.5		1.717	.146								
3	6.0	6.0	1.709	.103	.104	....	......	.811	52.67	100	1.124	85.15
4	6.0		1.753	.105								
5	19.3	16.4	1.639	.316	.274	.158	10.26	.850	55.19	104.8	1.075	84.00
6	13.5		1.717	.232								

*Omitted from average.

The residual crop is much smaller than the first crop, but, with few exceptions, the duplicate weights agree well. With one exception, that of series "D," the yield of dry matter with dried blood is greater than with nitrate of soda. For the years 1912 and 1913 this was true without exception. The yield from the check cylinders is greater than that from the nitrate cylinders in six out of ten series, though, in most cases, the differences are not great one way or the other. The explanation for the higher yield with the residual crop on the check cylinders seems to be found in the fact that the first crop not only uses up the nitrate that is applied to these cylinders, but, on account of stimulated growth, the plants are enabled to more thoroughly utilize the organic nitrogen of the soil and thus these cylinders are left in a more depleted condition with reference to supply of nitrogen than the check cylinders. This point was explained more fully in the report for 1913.

It is thus quite clear that one cannot depend upon the initial application of nitrate of soda to maintain the crop yield and nitrogen supply of the soil if a residual crop is to be grown. Either a second application of nitrate must be made or the second crop must be a legume. Neither does the initial application of dried blood prove sufficient to maintain the yield for a second crop, though, on account of its lower efficiency with the first crop, it may give higher yields than the nitrate with the second crop.

The highest yield, 34.8 grams, occurs with dried blood in series "F," with 50 per cent. of sand, and the next highest, 33.95 grams, with dried blood in series "A," pure shale, and the next with dried blood in series "E," with 40 per cent. sand. The lowest yield, 6 grams, is with nitrate of soda in series "J," pure sand, and the next lowest, 6.5 grams, with nitrate also in series "J." The highest average for any one series is 32.08 grams for series "F" and the next highest, 28.64 grams, for series "A." In this connection it may be remembered that the yield of barley for series "A" was unusually low.

The percentage of nitrogen in the buckwheat is distinctly higher than in the barley of the first crop. It will further be noted that the percentages run considerably higher in series "A," "B," "C" and "D," on an average, than in the remaining series, and this was also noted in connection with the barley.

The highest yield of nitrogen, 0.668 grams, occurs with dried blood in series "A," pure shale soil, and the next highest, .586, with dried blood in series "C," 20 per cent. sand.

The highest recoveries for both nitrate and dried blood occur in series "C," the recovery for nitrate being 19.74 per cent. and for dried blood 24.48 per cent. With the exception of this series, the recoveries for nitrate are small, or there is no recovery for this material, thus showing in most cases a high relative availability for dried blood in the residual crop.

A summary for the two crops shows an average recovery for nitrate of 64.366 per cent. and for blood of 54.97 per cent. The average availability for blood, when nitrate is taken at 100, is 85.66. The average total nitrogen for both crops is .70 gram for the check cylinders, 1.693 grams for the nitrate cylinders, and 1.546 grams for the dried blood cylinders. The highest amount of nitrogen recovered for both crops is 1.895 grams with nitrate of soda in series "B," with 10 per cent. of sand, and the next highest is 1.889 grams with nitrate of soda in series "F," 50 per cent. sand.

The yields of dry matter for the residual crop, and the yields of dry matter and percentage of nitrogen recovered, for the combined crops, are indicated by curves in Figs. 2 and 3 respectively.

The Theoretical and Actual Recoveries from the Shale Soil.

As in previous years a comparison of the amount of nitrogen which should be recovered from the organic matter of the shale soil where sand was introduced (as calculated from the recovery from pure shale), with the net amount actually recovered, is of interest.

Under "Total Nitrogen in Both Crops" it is seen that there was recovered from the check cylinders 1.021 gms. From the corresponding cylinders with pure sand there was a recovery of 0.225 gm. made up of traces which may have been in the sand, that which was contained in the seed, and any that may have been fixed by non-symbiotic bacteria. The difference between these amounts, 0.796, represents the actual net recovery from the shale soil cylinders.

Since the check cylinders of series "B" were 90 per cent. shale instead of pure shale the theoretical recovery from this should be 90 per cent. of 0.796, which is 0.716. The actual amount of nitrogen recovered in the combined crops from the check cylinders of series "B" was 1.060 gms. and subtracting from this 0.225 gm. (combined recovery from check cylinders in pure sand), we have 0.835 gm., which represents the net recovery from the shale soil of series "B." In a similar way we may calculate the theoretical and actual recoveries from the humus of the shale soil for the combined crops with various dilutions. These results are shown in Table V.

Table V—Nitrogen Recovered from Shale Soil in the Combined Crops.

COMPOSITION OF THE SOIL.	Theoretical Amount of Nitrogen Recovered. Gms.	Actual Amount of Nitrogen Recovered. Gms.
100 % Shale Soil	.796	.796
90 % " "	.716	.835
80 % " "	.637	.476
70 % " "	.557	.520
60 % " "	.478	.546
50 % " "	.398	.625
30 % " "	.239	.378
20 % " "	.159	.356
10 % " "	.079	.216
100 % sand.		

From this table we note that with two exceptions, namely, 80 and 70 per cent. of shale soil, the actual recoveries surpass the theoretical amounts as calculated from the recovery from the shale soil alone. It may be pointed out that the amount thus actually recovered is decidedly increased with the higher percentages of sand.

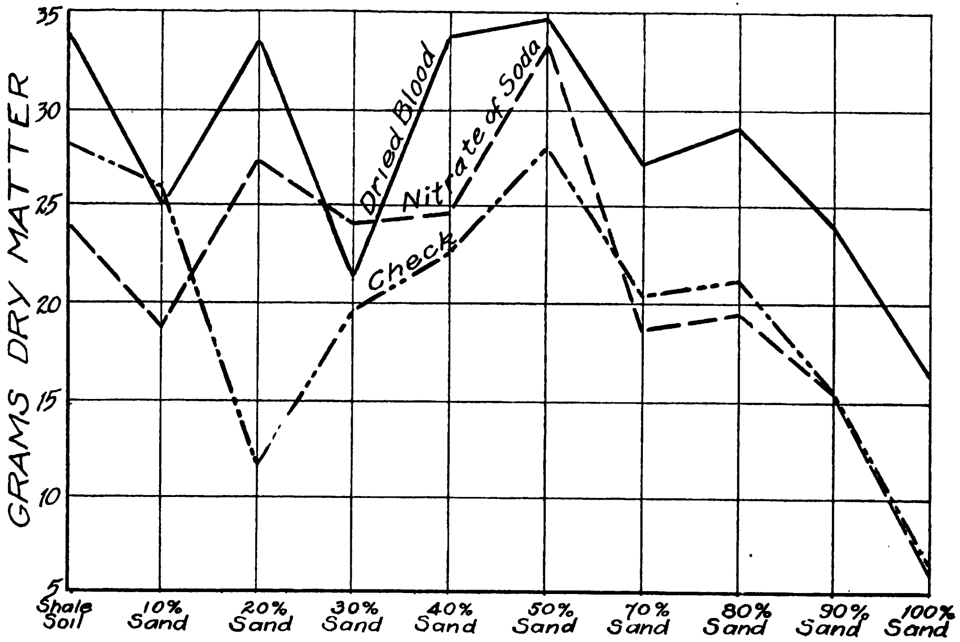

FIGURE 2.—Weight of Dry Matter in Residual Crop—Buckwheat.

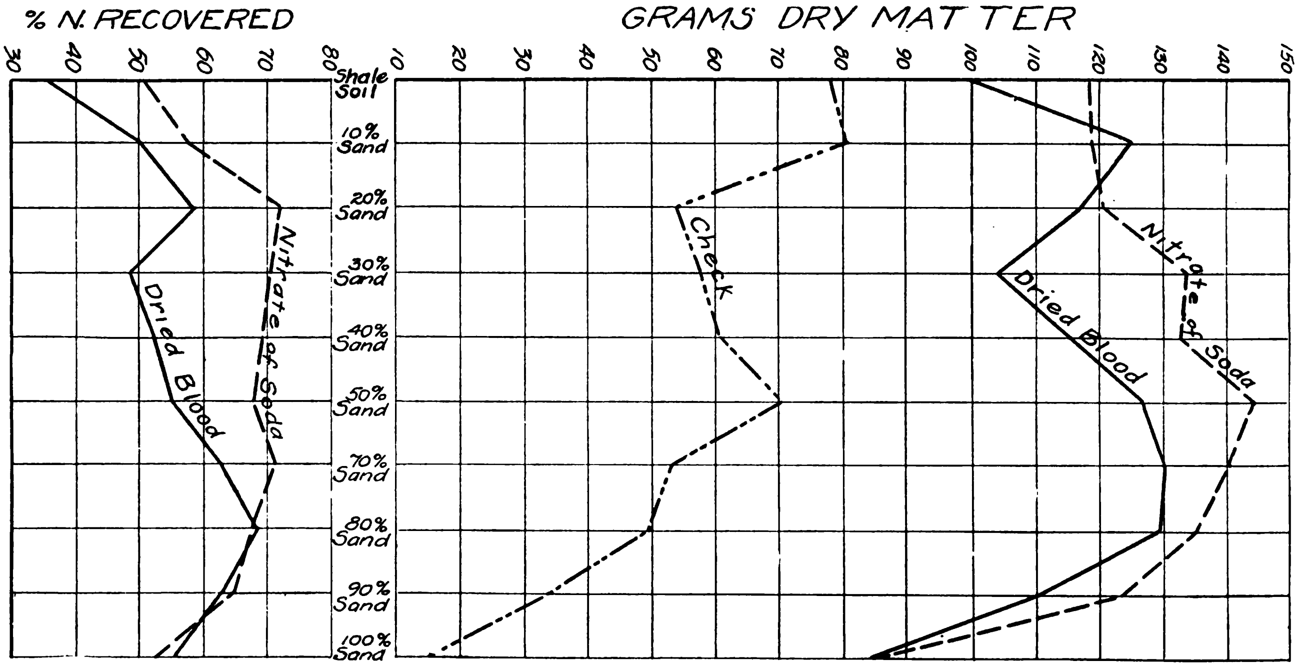

FIGURE 3.—Weight of Dry Matter and Per Cent. Nitrogen Recovered in Both Crops.

As pointed out in previous reports this clearly indicates an improved condition of the soil with the introduction of sand, due to better aeration, and therefore more complete utilization of the soil organic matter.

Summary.

1. This is a continuation of work begun in 1911 on the availability of nitrate of soda and dried blood when applied to shale soil and mixtures of sand and shale soil.

2. Nitrate of soda and dried blood when used on mixtures of sand and shale soil varying in proportion from 10 per cent. to 90 per cent. sand, give higher yields of dry matter and nitrogen in the first crop than when used with loam soil alone or sand alone.

3. With the first crop nitrate invariably gave higher yields than dried blood.

4. The average recovery of nitrogen with nitrate of soda for the first crop was 60.52 per cent., and with dried blood 43.92 per cent. The highest recovery with nitrate of soda was 71.17 per cent. where the mixture contained 70 per cent. of sand, and the highest recovery for dried blood was 56.3 per cent. with 80 per cent. sand.

5. Taking 100 as the availability of the nitrate of soda for this crop the availability of the dried blood was 72.07.

6. With the residual crop of buckwheat the yields from the check cylinders were in a number of cases larger than from the nitrate cylinders. This is apparently due to the fact that the nitrate was largely utilized by the first crop thus stimulating the crops of these cylinders to a more thorough utilization of the soil organic nitrogen than was possible on the check cylinders; therefore the check cylinders have as much available nitrogen and possibly more for the second crop than the nitrate of soda cylinders.

7. In four out of the ten series no nitrate nitrogen was recovered in the second crop and, with one exception, the recoveries from the other six were low. The average residual recovery from dried blood for all series was 11.05 per cent.

8. Notwithstanding this high recovery from dried blood with the residual crop, when the combined recoveries are considered the nitrate stands ahead in all series except "J," where sand alone was used. The average combined recovery is 64.37 per cent. for the nitrate of soda and 54.97 for dried blood.

9. With the combined crops the dried blood shows an availability of 85.66 when nitrate of soda is taken at 100.

10. From these results it is quite clear that we need not expect much residual effect from a moderate application of nitrate of soda. We may expect some residual effect from dried blood in nearly all cases, though the initial effect of nitrate is sufficiently above that of the dried blood to place the nitrate ahead when the combined recoveries are considered.

11. With these facts before him it would seem that the farmer could not afford to pay more for nitrogen in organic materials than in nitrate of soda.

12. Mixing sand with heavy soils permits a better aeration and drainage and results in a more complete utilization of the nitrogen of the soil organic matter.

THE INFLUENCE OF LIME ON THE YIELD OF DRY MATTER AND PERCENTAGE OF NITROGEN.

Earlier experiments* have shown that with acid soils lime not only increases the amount of dry matter but that it also increases the percentage of nitrogen in the dry matter. This experiment was planned to give further data in this connection with especial reference to leguminous crops.

The soil was a sandy loam containing some gravel and having a lime requirement of about 2,000 pounds per acre 6 2-3 inches.

Pots holding 18 pounds of soil were used, and all received 4 grams acid phosphate and 2 grams potassium sulphate. In addition to the general treatment, certain of the pots received ground limestone as indicated in the table, while three received nitrate of soda for comparison. The moisture was maintained at about 12 per cent. until the crop grew so large that it was impossible to regulate the supply accurately. The pots were seeded to Crimson Clover December 29 and this grew until it was about 18 inches high, and was in full bloom. It was then harvested, dried and weighed as usual. The yield of dry matter and nitrogen, together with other data are shown in Table VI.

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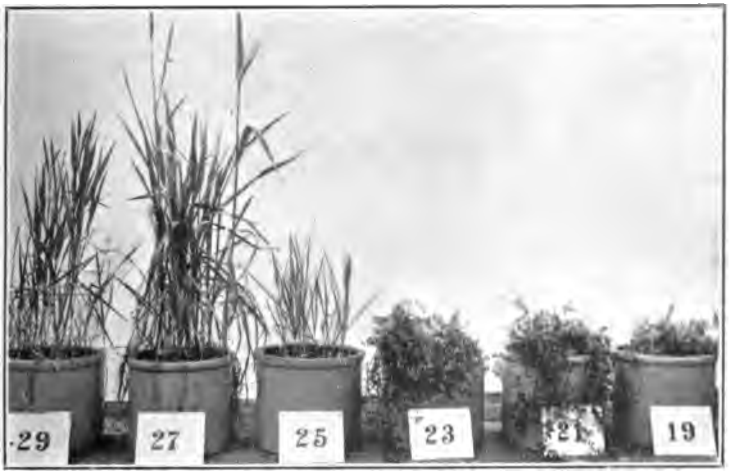
*Field Experiments on the Availability of Nitrogenous Fertilizers, Lipman and Blair, Bulletin No. 260, N. J. Agri. Expt. Sta. pp. 11-12.

PLATE A.



$CaCo_3$ $NaNo_3$ Check $CaCo_3$ $NaNo_3$ Check

Vetch and Barley on an Acid Soil. Lime Aids in Making the Nitrogen of the Soil Organic Matter Available.

Table VI—The Yield of Dry Matter and Nitrogen as Influenced by Lime—Leguminous Crops.

		FIRST CROP—CRIMSON CLOVER 1913-14.				RESIDUAL CROP—SOYBEANS 1914.			
Pot number.	SPECIAL TREATMENT.	Dry matter gms.	Per cent. nitrogen.	Average nitrogen mgs.	Per cent. increase over check, nitrogen	Dry matter gms.	Per cent. nitrogen.	Average nitrogen mgs.	Per cent increase over check, nitrogen.
1	No lime (check).............	28.8	1.697	......	......	10.0	1.552	......	......
2		24.1	1.707	437.24	......	11.7	1.639	149.35	......
3		22.2	1.854	......	......	7.2	1.404	......	......
4	2 gms. nitrate of soda........	35.5	1.844	......	......	7.7	1.491	......	......
5		30.9	1.727	564.21	29.04	7.2	1.264	116.21	......
6		28.4	1.776	......	......	9.4	1.413	......	......
7	10 gms. ground limestone.....	42.6	2.119	......	......	28.0	2.808	......	......
8		36.2	2.099	811.94	85.69	17.2	2.197	473.94	217.33
9		36.0	2.148	......	......	15.5	1.727	......	......
10	25 gms. ground limestone.....	39.7	2.070	......	......	25.0	2.006	......	......
11		38.0	2.237	812.28	85.77	21.2	1.997	458.08	206.71
12		37.5	2.040	......	......	24.2	1.857	......	......
13	50 gms. ground limestone.....	33.0	2.139	......	......	25.5	2.197	......	......
14		37.7	2.227	765.78	75.14	27.0	2.032	524.27	251.04
15		36.5	2.060	......	......	28.0	2.014	......	......
16	100 gms. ground limestone....	38.4	2.060	......	......	27.5	2.163	......	......
17		36.8	2.217	794.15	81.63	23.0	2.049	574.68	284.79
18		36.6	2.119	......	......	25.7	2.171	......	......

In all cases where lime was used the average yield of dry matter is at least 10 grams more than where no lime was used. The difference in yield with 10 grams and 100 grams of limestone is not great, the highest yield being with 25 grams. Also the yield is higher with 2 grams of nitrate of soda than on the check. The percentage of nitrogen is likewise distinctly higher with lime than without, the average for no lime being 1.75 per cent. and the average with lime being, in all cases, more than 2 per cent. The highest yield of nitrogen, as of dry matter, is with 25 grams of limestone. It is of interest to note that while the nitrate of soda has given an increased yield of nitrogen, over the check, of 29.04 per cent. with lime, the increased yields over check amount to 75 to 85 per cent.

Residual Crop.

Following the crimson clover, soy beans were seeded in the pots without further addition of fertilizers or lime. The beans were seeded about the 1st of June and harvested the 4th of September. The pods had fully formed at this time, but seeds had not ripened so that stalks and pods were harvested together as forage. The dry weights, percentage of nitrogen, and other data are shown in the table above. Here the limed pots show more than double the yield of dry matter given by the check pots, while the nitrate of soda pots yielded less than the check. The highest yield in this case is with 50 grams of limestone and the next highest with 100 grams.

While the percentage of nitrogen is not quite so high as in the preceding crop of clover, it is still higher in the limed than in the unlimed pots, the average of the latter being 1.54 per cent., while the former, with slight exception, show more than 2 per cent. of nitrogen. The average percentage with nitrate of soda is even less than for the check. The highest yield of nitrogen is with 100 grams of limestone. In all cases where limestone was used the increase of nitrogen over the check, as shown by the yield, amounts to more than 200 per cent., and where 100 grams of limestone were used it amounts to nearly 300 per cent.

Should the use of lime in this way result in depleting the nitrogen supply of the soil—and this is undoubtedly what would happen with the growing of non-leguminous crops only—it would finally mean ruined and abandoned farms, but if leguminous crops are frequently introduced in the rotation, or better, if the main crop of the rotation is followed by a legume as often as possible, the liberal use of lime will not only mean increased yields, but also increased feeding value as shown by the higher nitrogen content, which means higher protein content.

If to secure this higher protein content one must rely upon commercial nitrogenous materials, the increase may not always prove profitable, but where it can be secured through the growing of leguminous crops, which take their nitrogen largely from the air, it means increased feeding value without increased cost. The fact that the gain in nitrogen over the check, with the residual crop is much greater than with the first crop indicates clearly that the soil is not being exhausted, but rather that nitrogen is being added to it.

THE EFFECT OF LARGE APPLICATIONS OF GROUND LIMESTONE ON THE YIELD AND NITROGEN CONTENT OF DRY MATTER.

The experiment was conducted in earthenware pots holding approximately 16 to 18 pounds of soil, depending upon the amount of limestone added. To all pots there were added four grams acid phosphate and two grams potassium sulphate, these materials being thoroughly mixed with the soil. Ground limestone was mixed with the soil for certain of the pots as indicated in the table under "Special Treatment." The pots were seeded to barley early in December, 1913, and the crop grown to maturity. Throughout the growing period the moisture content of the soil was maintained at as nearly the optimum condition as possible. At maturity the crop was harvested, dried, weighed and samples prepared for nitrogen determinations.

The special treatment given and the results secured are shown in Table VII.

Table VII—The Influence of Ground Limestone on the Yield and Nitrogen Content of Barley.

Pot No.	SPECIAL TREATMENT.	DRY MATTER GRAMS.		Per cent. Nitrog.	NITROGEN MGS.		Increase over check mgs.
		Per pot	Average		Per pot	Average	
1	No limestone.	9.7	9.85	0.984	95.45	95.43	
2		10.0		0.954	95.40		
3	2 gms. $NaNO_3$	21.0	20.90	1.564	328.44	324.80	229.37
4	(No limestone)	20.8		1.544	321.15		
5	10 gms. ground.	12.7	12.35	0.964	122.43	120.26	24.83
6	Limestone (.12%).	12.0		0.984	118.08		
7	81.7 grams ground.	22.0	22.90	1.111	244.42	240.38	144.95
8	Limestone (1%).	23.8		0.993	236.33		
9	163.4 grams ground.	20.0	20.75	1.161	232.20	233.49	138.06
10	Limestone (2%).	21.5		1.092	234.78		
11	408.6 grams ground.	21.2	21.85	1.082	229.38	223.14	127.71
12	Limestone (5%).	22.5		0.964	216.90		
13	817.2 grams ground.	23.9	22.70	0.984	235.18	209.61	114.18
14	Limestone (10%).	21.5		0.856	184.04		

Yield of Dry Matter.

The highest average yield of dry matter was obtained with one per cent. of limestone in the soil, though a yield practically as high was obtained with ten per cent. of limestone. In pots 5 and 6 with .12 per cent. of limestone the yield is only a little higher than with no limestone. With two grams of nitrate of soda the yield is nearly as great as with one per cent. of limestone.

Percentage of Nitrogen.

The highest average percentage of nitrogen, 1.55, occurs with the nitrate of soda. In all cases except one—pots 13 and 14—the average percentage where lime was used is higher than where no lime was used. Excepting the nitrate of soda pots, the highest percentage of nitrogen occurs with two per cent. of limestone. The greatest increase in yield over the check is shown with nitrate of soda. The next greatest increase is with pots 7 and 8 where one per cent. of limestone was used. With heavier applications of limestone the increase over the check becomes gradually less though an unusually low percentage of nitrogen in pot 14 is partly responsible for this. The increase with .12 per cent. of limestone is slight.

Conclusion.

Applications of limestone ranging from one per cent. to ten per cent. gave yields of dry matter which are more than double the yield without limestone and slightly in excess of the yield with nitrate of soda. In other words the soil gave a better response with heavy applications of limestone than with a fair application of nitrate of soda. With applications of limestone the percentage of nitrogen in the dry matter was not so high as with nitrate of soda, but somewhat higher, on the average, than without limestone. It is quite clear that the presence, in the soil, of an abundant supply of limestone has enabled the plants to utilize to better advantage the nitrogen of soil organic matter. It is likewise clear that the long continued use of limestone in this way, without the addition of new supplies of organic matter in some form, would ultimately result in the depletion and

exhaustion of the nitrogen supply of the soil. On the other hand the liberal use of stable manure or preferably the frequent growing of leguminous crops for forage or as green manure would largely supply the nitrogen, while the limestone would, as is plainly demonstrated in this experiment, aid in making it available as a plant food. The influence of lime in making available the organic matter of the soil is clearly brought out in the accompanying photograph.

FACTORS INFLUENCING THE PROTEIN CONTENT OF SOYBEANS

During the summer of 1914 a number of pot experiments were conducted to determine the influence of different factors, as for example, fertilizer treatment, thickness of planting, time of harvesting, etc., on the protein content of soy beans. The crops were grown in pots holding about 20 pounds of soil or sand, and lime and minerals (phosphoric acid and potash) were added to all pots except certain ones where these materials were being tested.

Thickness of Planting. This experiment was carried out in soil, and also in sand. In each case all pots received 4 grams acid phosphate, 2 grams potassium sulphate and 10 grams finely ground limestone. For the sand there was also added to each pot 0.5 gram magnesium sulphate and 0.25 gram ferric sulphate. All pots were inoculated with an infusion made from soil taken from a field where soy beans had previously been grown. Moisture was maintained at about 15 to 16 per cent. for the soil and about 10 per cent. for the sand. The crops were grown until the pods were fully formed, but were harvested as forage before the beans had ripened. The results from the soil and sand are shown in Table I.

Table I—Influence of Thickness of Planting on Protein Content of Soy Beans.

No.	PLANTS PER POT.	GROWN IN SOIL.					GROWN IN SAND.				
		Dry matter gms.		Per cent. nitrogen.	Nitrogen gms.		Dry matter gms.		Per cent nitrogen.	Nitrogen gms.	
		Per pot.	Average.		Per pot.	Average.	Per pot.	Average.		Per Pot.	Average.
1	2..........	39.4	43.83	3.477	1.370	1.503	4.5	4.83	3.321	.149	.143
2		41.7		3.450	1.439		6.0		2.804	.168	
3		50.4		3.372	1.699		4.0		2.777	.111	
4	5..........	48.4	49.53	3.468	1.679	1.753	9.0	9.17	3.023	.272	.293
5		50.0		3.485	1.743		10.5		3.345	.351	
6		50.2		3.661	1.838		8.0		3.188	.255	
7	8..........	54.0	54.13	3.415	1.844	1.804	15.5	12.17	3.599	.558	.407
8		52.2		3.310	1.728		13.5		3.389	.458	
9		56.2		3.275	1.841		7.5		2.715	.204	
10	12..........	60.4	58.80	3.284	1.984	1.978	20.0	22.17	3.433	.687	.761
11		55.0		3.317	1.824		24.5		3.363	.824	
12		61.0		3.485	2.126		22.0		3.503	.771	
13	20..........	63.5	68.50	3.380	2.146	2.300	30.5	33.67	3.363	1.026	1.117
14		68.0		3.275	2.227		33.5		3.450	1.156	
15		74.0		3.415	2.527		37.0		3.161	1.170	

The rate of seeding varied from two plants per pot to twenty per pot. They were originally planted at the rate of 5, 8, 12, 16, and 25 per pot, but were later thinned to the numbers shown in the table.

In both cases the yield of dry matter increased with the increase in planting, and the increase is much more rapid with sand than with soil. The average yield for the three pots with two plants in soil is 43.85 grams and for twenty plants is 65.8 grams. The average yield for the three pots with two plants in sand is 4.83 grams and for twenty plants it is 33.67 grams.

With soil the percentage of nitrogen in all cases is above three per cent. —the average being close to three and a half—with a slight tendency to a higher percentage with the thinner plantings. With sand the plantings from eight to twenty give slightly higher percentages than those from two to five. Here the lowest yield and lowest average percentage of nitrogen is with two plants per pot.

In our earlier work we have noted quite frequently when growing barley in pots, that the dry matter from pots in which only a few plants grew contained a higher percentage of nitrogen than the dry matter from pots in which the full number of plants grew. That is, there seemed to be a tendency for the few plants to take up the nitrogen which the larger number of plants would have gotten had they been present. This does not seem to be so true of the leguminous plants and may mean that in association of numbers there is increased or intensified utilization of atmospheric nitrogen. If this be true the importance of thick seeding in the case of leguminous crops is at once apparent. It is certainly clear that for a given area there is much more nitrogen recovered in the crop with thick than with thin seeding. Thus with soil the amount with twenty seeds to the pot is about one and one-half times the amount with two seeds per pot, and with sand the amount with twenty seeds is about eight times the amount with two seeds. The necessity for thick seeding in sandy soils seems to be especially emphasized.

Date of Harvesting. In this experiment soil only was used, and the fertilizer and lime treatment were the same as with the soil in the previous experiments. All pots were inoculated with an infusion made from the soil taken from a field where soy beans had grown. A sufficient number of pots were prepared to allow cuttings 6, 8, 10, 12, 15 and 18 weeks from date of planting. In harvesting, the stalks were cut as for forage; the soil was then removed from the pots, thoroughly washed away from the roots which were then dried and weighed separately. The variety used was the Guelph. The seeds were planted the 28th of May and the first three pots harvested July 9. The dry weight of the crop, percentage of nitrogen and other data are shown in Table II.

Table II—Protein Content of Soy Beans as affected by Date of Harvesting.

No.	TIME OF HARVESTING	DRY WEIGHT GRAMS.				% NITROGEN.		TOTAL NITROGEN, GRAMS.	
		Tops		Roots					
		Per pot.	Av'ge	Per pot.	Av'ge	Tops.	Roots.	Per pot.	Av'ge
1	6 weeks after planting (July 9)	13.4	12.13	2.8	2.67	2.620	2.445	.419	.380
2		12.2		2.8		2.567	2.313	.378	
3		10.8		2.4		2.655	2.366	.344	
4	8 weeks after planting (July 23)	21.5	20.53	5.9	5.40	2.951	2.839	.802	.770
5		22.5		5.3		3.181	2.970	.873	
6		17.6		5.0		2.892	2.515	.635	
7	10 weeks after planting (Aug. 6)	41.7	38.30	8.3	7.40	3.452	3.190	1.704	1.54
8		39.0		7.7		3.356	3.197	1.555	
9		34.2		6.2		3.470	3.119	1.380	
10	12 weeks after planting (Aug. 20)	31.5	27.77	*7.4	6.93	2.550	2.918	1.019	*0.918
11		21.7		6.7		2.628	2.699	0.751	
12		30.1		6.7		2.638	2.830	0.984	
13	15 weeks after planting (Sept. 10)	59.0	61.93	4.0	5.47	3.487	1.816	2.130	2.231
14		63.0		7.4		3.610	2.103	2.430	
15		63.8		5.0		3.172	2.191	2.134	
16	18 weeks after planting (Oct. 1)	58.0	55.93	5.0	5.33	3.026	1.884	1.849	1.873
17		67.7		7.0		3.410	1.953	2.446	
18		42.1		4.0		2.982	1.727	1.324	

*Injured by rats—roots were not injured.

Referring to the dry weight of the tops, it will be noted that with but one exception (where plants were injured) there is a gradual increase from the end of the 6th week to the end of the 15th week, with a slight decrease from the 15th to the 18th, the maximum average weight being 61.93 grams. The maximum average weight for the roots occurs at the end of the 10th week, with a gradual decrease from that time to the end of the 18th week.

The percentage of nitrogen in the tops reaches the average of 3.43 at the end of the 10th week and 3.42 at the end of the 15th week. The low percentage from those harvested August 20 must be attributed to the fact that while these were drying a part of the beans were eaten by rats, thus lowering the percentage of nitrogen and also affecting the weight of dry matter. With this exception the lowest average, 2.61, occurs at the end of the 6th week. A slight decrease in the percentage of nitrogen from the 15th to the 18th week may be attributed to the loss of leaves.

The percentage of nitrogen in the roots reaches a maximum at the end of ten weeks with an average of 3.17. From this date there is a gradual decrease to the end of the 18th week, when the average is 1.85. This decrease is undoubtedly due to the gradual decay and disintegration of the nodules and smaller roots, which could not be saved as the plants became older. This does not necessarily mean that nitrogen has been lost, but that it remains in the soil rather than in the roots, which were taken out of the soil.

From these results it is quite evident that if the beans are to be harvested at forage, harvesting from the end of the 10th to the 15th week will result in giving the maximum protein content. Earlier than the 10th week they have not sufficiently matured to give the maximum percentage of nitrogen, and after the 15th week the loss of the leaves may result in a lower percentage since the leaves are richer in nitrogen than the stems.

Different Fertilizer Materials. In this experiment loam soil was used as in the two previous experiments, and all pots received 4 gms. potassium sulphate, and all were inoculated as in the previous experiments. Three pots were prepared without fertilizer, as a check, and the others received different fertilizing materials as indicated in the table which follows. On May 7th twelve Guelph soy beans were planted in each pot and later they were thinned to ten plants.

On August 14 it was noted that all plants had a good green color, and that all pods were filled, and growth had about ceased. The plants in the check pots were about 16 inches high, and all others about 19 inches high. On the 26th of August the crop was harvested, the plants dried and ground for analysis. The dry matter, percentage of nitrogen, and data with reference to the fertilizer treatment are shown in Table III.

Table III—Protein Content of Soy Beans as Affected by Different Fertilizers.

No.	SPECIAL TREATMENT.	DRY MATTER GMS.		Per cent. Nitrogen	NITROGEN.	
		Per pot	Average		Per pot	Average
1	Check	56.7	52.07	3.258	1.847	1.684
2		45.5		3.302	1.502	
3		54.0		3.153	1.703	
4	2 gms. $NaNO_3$ (15.93% N)	49.0	50.07	3.398	1.665	1.630
5		53.9		3.188	1.718	
6		47.3		3.188	1.508	
7	4 gms. $NaNO_3$ (15.93% N)	54.2	54.23	3.310	1.793	1.796
8		54.5		3.179	1.733	
9		54.0		3.450	1.863	
10	10 gms. $CaCO_3$	52.0	51.67	3.345	1.739	1.729
11		55.0		3.337	1.835	
12		48.0		3.363	1.614	
13	25 gms. $CaCO_3$	48.7	50.33	3.354	1.633	1.667
14		49.7		3.275	1.628	
15		52.6		3.310	1.741	
16	4 gms. Acid Phosphate	49.5	46.47	3.083	1.526	1.519
17		38.2		3.302	1.261	
18		51.7		3.424	1.770	
19	8 gms. Acid Phosphate	52.7	50.47	3.389	1.786	1.655
20		51.2		3.170	1.623	
21		47.5		3.275	1.556	
22	2 gms. $CaSO_4$	47.5	50.17	3.310	1.572	1.617
23		50.0		3.232	1.616	
24		53.0		3.135	1.662	
25	4 gms. $CaSO_4$	54.0	55.70	3.170	1.712	1.740
26		54.5		3.187	1.737	
27		58.6		3.021	1.770	

From this table it will be noted that the yield of dry matter is quite constant. The maximum yield of 55.7 gms. occurs with 4 gms. calcium sulphate; while with 4 gms. nitrate of soda the yield is almost as high. The average yield from the check pots is 52.07 gms. which is slightly higher than on some of the pots that received fertilizer.

The percentage of nitrogen is also fairly constant, and it is interesting to note that in no case does it fall below three per cent. The maximum from a single pot is 3.45 where 4 gms. nitrate of soda was applied; the maximum average, 3.348, occurs where 10 gms. calcium carbonate was used, and the average with 25 gms. is only slightly less. The lowest average, 3.126, is found with 4 gms. calcium sulphate. These pots, however, gave the highest yield of dry matter thus placing the yield of total nitrogen in second place, the highest yield occurring with 4 gms. nitrate of soda. It is of especial interest to note that the limestone gives higher percentages of nitrogen, on an average, than the nitrate of soda, thus emphasizing the value of an abundant supply of limestone in the accumulation of atmospheric nitrogen, and also making it clear that it is not necessary to add nitrogenous fertilizers in the growing of soy beans, provided the soil is well supplied with lime.

Varieties. For this work pots holding twenty pounds of loam soil were used. All pots received 4 gms. acid phosphate, 2 gms. potassium sulphate, and 10 gms. ground limestone. All were inoculated as in the other experiments. Eleven different varieties were planted as indicated in the table which follows. These were harvested as forage but all were not harvested at the same time, as some matured earlier than others. An effort was made to harvest all at about the same stage of maturity, that is after pods had fully formed but before leaves began to fall or beans to shatter out. The weights of dry matter, percentage of nitrogen, and total nitrogen are shown in Table IV.

Table IV—Protein Content of Different Varieties of Soy Beans.

No.	VARIETY.	DRY MATTER GMS.		Per cent. Nitrogen	Nitrogen Per pot, Grams	Average Grams
		Per pot	Average			
1	Claud	70.0	64.67	2.505	1.754	1.677
2		58.0		2.811	1.630	
3		66.0		2.496	1.647	
4	Ebony	37.5	41.83	3.608	1.353	1.445
5		47.5		3.380	1.606	
6		40.5		3.398	1.376	
7	Edna	55.0	53.67	3.196	1.758	1.720
8		54.0		3.144	1.698	
9		52.0		3.275	1.703	
10	Guelph	59.2	57.13	3.415	2.022	1.892
11		57.0		3.205	1.827	
12		55.2		3.310	1.827	
13	Hollybrook	78.4	78.60	3.126	2.451	2.455
14		74.5		3.118	2.323	
15		82.9		3.126	2.591	
16	Manhattan	39.0	38.83	3.153	1.230	1.242
17		43.0		3.161	1.359	
18		34.5		3.293	1.136	
19	Medium Yellow	54.5	49.57	3.328	1.814	1.639
20		43.2		3.267	1.411	
21		51.0		3.319	1.693	
22	Ohio 9035	75.8	77.27	2.872	2.177	2.168
23		82.0		2.802	2.298	
24		74.0		2.741	2.028	
25	Swan	95.0	92.77	2.802	2.662	2.560
26		93.8		2.583	2.423	
27		89.5		2.899	2.595	
28	Wilson	61.7	63.13	2.400	1.481	1.586
29		62.2		2.592	1.612	
30		65.5		2.540	1.664	
31	Tar Heel	130.5	121.53	2.415	3.152	3.010
32		109.6		2.511	2.752	
33		124.5		2.511	3.126	

The average weight of dry matter for the different varieties varies from 38.83 gms. with Manhattan to 121.53 gms. with Tarheel. The weights taken from the three pots with any one variety agree fairly well in most cases, showing a fair uniformity of growth.

There is a rather wide variation in the percentage of nitrogen in the different varieties. The Medium Yellow, Ebony, and Guelph show above 3.25 per cent. of nitrogen; the Edna and Manhattan show an average of more than 3 per cent. The Ohio 9035 and Swan show an average of more than 2.75 per cent.; the Claude and Wilson, more than 2.50 per cent.; and the Tarheel shows a average of more than 2.25 per cent. It should be observed than in most cases the percentage of nitrogen in a particular variety runs quite constant. It is of interest to note that the Tarheel, which gives the highest yield of dry matter, shows the lowest percentage of nitrogen. Since this variety does not mature well in this latitude it would not be well adapted for growth if seed were desired. If, however, it were to be used as a forage or green manure crop, its rank growth would probably result in adding to the soil more nitrogen than would be added by some of the smaller varieties. Certainly this was true in this case, for there was recovered in the crop 3.01 grams as against 2.56 grams for the Swan, which was the next highest. The Guelph, with a recovery of 2.45 grams, stands third. The Ebony and Manhattan both produced small plants, and have this much against them if one is considering the enrichment of the soil. The Tarheel, Swan, Hollybrook, and Ohio 9035 all show a recovery of nitrogen in the crop of above two grams.

Experiments With Fertilizers on Cranberries.

JOHN H. VOORHEES.

The study of the fertilization of cranberries started a year ago has been continued this year. It will be remembered that a complete outline of this experimental work is given in last year's report. The first application of fertiliser was made during 1913, and two years' results are now available. These experiments are all located upon bogs owned privately and the work is done co-operatively. Under such a system it is not always possible to control all factors which may in one way or another influence the yield of berries which is of primary interest to the growers. During 1913 series A, B and C, located on a Savanna bottom, deep mud bottom, and deep mud underlaid with iron deposits respectively were comparatively free from limiting factors other than plant food. Series D and E, however, were injured during the season by frost, weeds, insects and scald. This year, 1914, it has been impossible to make plant-food the only limiting factor on any of the series, and the yields were so influenced by outside factors, and in some cases so small, that they are of little value from a practical point of view. Many lessons have been gained, however, by observation of the growth of vine on the various plots treated differently and some interesting data has been collected regarding not only growth and development of vine, but also the effect of fertilizers upon such important controlling factors as insect pests, frosts, weeds, irrigation, drainage, etc.

Series A, located on a Savanna bottom on the lower and upper Meade bogs owned by Joseph J. White, at Whitebogs, N. J., was seriously attacked by the fire worm and bloom worm during the summer months, and yet, the yields were large enough to show clearly the advantage of fertilization by increasing both the size and yield of berries. It was impossible to measure in any way the injury caused by these pests, but the writer found the insects scattered generally over the entire series of plots. That the injury was large was evident from the number of insects present. Preventative measures were used by spraying with arsenical poisons but this was not done until much injury had been accomplished. Arsenical poisons seemed very effective in controlling the bloom worm, but the fire worm was not so easily combated. This invasion of insects was probably much greater than it would have been had there been sufficient water for reflowing at the time of their first appearance.

The following table gives the results of picking and records the size tests for 1913 and 1914. In explanation of these results which are recorded in pounds, it has been found that one pound of berries will approximate very closely one quart. The size tests were made by counting the number of berries, as they came from the picker, necessary to fill the small cup furnished to members of the Growers Cranberry Company by the American Cranberry Exchange. Three cups of berries from each plot were counted, and the average of the three counts computed to give the average size of berries. All berries are included in the picking regardless of size, insect or other injury, in order to get the weight of the entire crop. Series "A" has shown little scald or insect injury to the berries.

Series "A" Savanna Bottom—J. J. White's Bog.
Size of Plots: One-Twentieth Acre.

No. of Plot.	Application or Treatment.	1913			1914		
		Cost of Fertilizer in Cents.	Yield per Plot in Pounds.	Average Size of Berries.	Cost of Fertilizer in Cents.	Yield per Plot in Pounds.	Average Size of Berries.
1	14 lbs. Nitrate of Soda.	38	230.75	105	35	73.00	111
2	Nothing.	..	186.75	126	..	79.25	112
3	10 lbs. Ammonium Sulphate.	37	190.00	116	36	71.50	116
4	Nothing.	..	176.00	118	..	94.50	120
5	20 lbs. Dried Blood.	45	183.25	112	47	85.50	109
6	Nothing	..	209.00	118	..	73.75	118
7	30 lbs. Cotton Seed Meal.	55	211.00	120	52	77.00	110
8	Nothing.	..	191.00	112	..	82.00	113
9	14 lbs. Nitrate of Soda. 25 lbs. Acid-Phosphate. 10 lbs. Muriate of Potash.	73	250.75	...	71	94.75	94
10	Nothing.	..	163.50	128	..	60.25	119
11	10 lbs. Ammonium Sulphate. 25 lbs. Acid Phosphate. 10 lbs. Muriate of Potash.	72	159.50	97	72	53.50	104
12	Nothing.	..	144.25	...	..	41.00	117
13	20 lbs. Dried Blood. 25 lbs. Acid Phosphate. 10 lbs. Muriate of Potash	80	299.25	116	83	56.75	103
14	Nothing.	..	180.25	121	..	66.00	124
15	30 lbs. Cotton Seed Meal. 25 lbs. Acid Phosphate. 10 lbs. Muriate of Potash.	90	236.75	95	88	77.50	106
16	Nothing	..	154.00	115	..	43.25	117
17	25 lbs Acid Phosphate.	15	134.00	118	15	67.25	115
18	Nothing.	..	111.75	127	..	45.00	114
19	25 lbs. Basic Slag.	18	121.00	112	19	52.50	121
20	Nothing.	..	99.75	116	..	46.00	112
21	15 lbs. Phosphate Rock.	09	95.50	112	09	67.25	105
22	Nothing.	..	101.75	112	..	54.75	116
23	15 lbs. Steamed Bone.	23	137.50	108	23	81.75	113
24	Nothing.	..	132.25	118	..	82.50	112
25	30 lbs. Bone Meal 2–30. 10 lbs. Ammonium Sulphate. 10 lbs. Muriate of Potash.	93	92.75	116	94	119.25	104
26	Nothing.	..	90.25	139	..	108.50	113
27	25 lbs. Basis Slag. 10 lbs. Nitrate of Soda. 10 lbs. Muriate of Potash	77	272.25	112	75	174.25	92
28	Nothing.	..	241.75	111	..	82.50	114
29	15 lbs Phosphate Rock. 10 lbs. Ammonium Sulphate. 10 lbs. Muriate of Potash	66	263.00	117	66	154.75	102
30	Nothing.	..	226.25	120	..	120.75	115
31	15 lbs. Steamed Bone. 10 lbs. Ammonium Sulphate. 10 lbs. Murate of Potash.	80	213.25	112	80	108.75	92
32	Nothing.	..	194.75	115	..	90.00	119
33	10 lbs. Muriate of Potash.	20	267.25	100	21	75.50	101
34	Nothing.	..	258.75	113	..	102.25	114
35	10 lbs. Sulphate of Potash	22	169.00	107	24	152.50	120
36	Nothing.	..	132.25	123	..	114.00	119
37	42 lbs. Kainit	23	158.50	113	24	135.50	111
38	Nothing.	..	122.25	123	..	117.75	114
39	10 lbs. Sulphate of Potash. 10 lbs. Ammonium Sulphate. 25 lbs. Acid Phosphate.	75	179.25	107	76	149.25	106
40	Nothing.	..	137.00	117	..	178.50	109
41	42 lbs. Kainit. 10 lbs. Ammonium Sulphate. 25 lbs. Acid Phosphate.	76	144.25	111	75	154.00	104
42	Nothing.	....	102.00	122	..	133.75	118

By compiling thefigures given in the table above it may be noted that the use of fertilizer supplying all three elements of plant food on plots 9, 11, 13, 15, 25, 27, 29, 31, 39 and 41 caused an average increase in yield of 29% in 1913 and 23% in 1914, while at the same time there was an average increase in size of ten per cent. in 1913, and fifteen per cent. in 1914. It should be remembered in this connection that the fertilizer was not applied until June 1913, whereas the fruit buds had been formed the previous year for the 1913 crop, so that the increase in yield must have been caused first by an increase in size, and second, by a strengthening of the vines, which undoubtedly enabled them to bring more berries to maturity. During 1914 there may have been more fruit buds formed, but if this is true, the writer has been unable to observe it or to make any definite record to that effect.

On plots 1, 3, 5 and 7, which received only nitrogen, there was an average increase in yield over the check-plots of six per cent. in 1913, and an average decrease of seven per cent. in 1914, while at the same time the increase in size was five and three per cent. respectively. The growth of vine on these plots was enormous considering the fact that only nitrogen was applied, and runners were very numerous. This shows clearly that nitrogen at the rate of forty pounds per acre applied alone is excessive, and tends to cause runners to grow at the expense of fruit bud formation and fruit development.

Plots 17, 19, 21 and 23, which received phosphoric acid in different forms, showed an increase of nine per cent. in average yield in 1913; and eighteen per cent. in 1914. The size of the berries increased five per cent. in 1913, but showed no increase in 1914, probably due to the larger number. Plots 33, 35 and 37 receiving potash only, showed an average increase in yield in 1913 of fifteen per cent., and eight per cent. in 1914, while in the same years the size increased twelve and five per cent. respectively.

Regarding the source and form of the various materials used for supplying plant-food, observations of growth indicate that nitrate of soda, acid phosphate, and muriate of potash, have produced more nearly the growth desired than any other materials, though judgment should be used in determining the amount of nitrogen supplied. Upon soils other than the light sandy Savanna bottom, forty pounds of nitrogen per acre in either nitrate of soda or ammonium sulphate caused an excessive growth of vine, especially runners. In another series located at Jamesburg the yields almost decreased to nothing. Appearances of growth show that phosphate rock produced nearly as good growth as either acid phosphate or basic slag, and further experimentation may prove it to be of value on bog soils which are acid in nature, because it is much less costly. Plot 21 upon which it was used showed very clearly that it takes very nearly a year to become available in any sufficient amount to cause an increase in yield or size. During the second year, however, it caused an increase in yield over its check No. 22 of twenty-four per cent., and an increase in size of ten per cent.

INDIRECT AFFECT OF FERTILIZATION.

While this test and others similar to it were planned to study primarily the effect of the fertilization of cranberries, there are a number of incidental observations the writer has made which bear directly upon the industry. As early as September a year ago the vitality of weeds, mostly sedges, seemed to be weakened. Four plots on John W. Vohman's bog at Jamesburg which are fertilized with complete mixtures have grown excessively, too much in fact, but this excessive growth has crowded the weeds almost entirely out. Red root, a weed which is very serious in many bogs of the State, has suffered severely and it is hoped that fertilization will prove to be a capable means of destroying this weed. The effect of fertilization upon it was first noticed in plots on the Pole Bridge bog owned by Joseph J. White. During June and July 1914, the year old stalks of this weed could be located and distinguished almost anywhere in the series of plots. Wherever the growth of vine had been stimulated by fertilization there were few new plants coming up. On the contrary, where no fertilizer had been applied, the growth of the new plants appeared normal.

It is also the writer's belief that fertilization will strengthen the vines so materially that they will be better able to withstand frost and insect injury. It was observed this year that fertilized vines recovered very quickly from slight frost injury. Where the injury was very severe new uprights were produced to take the place of the frozen ones. On the other hand, the increase of organic matter which accumulates on fertilized plots forms very favorable conditions for the protection and development of the girdle worm which is already spreading in many plots. It is believed that sanding will prove an efficient remedy for this trouble, and a prevention against spread of the insect. The advisability of this method is doubtful, however, because it is generally believed that sanding makes conditions favorable for the development and spread of diseases. There is no definite information on this point. Cape Cod growers are today experiencing much trouble with cranberry diseases, believed by many to be brought about by increased sanding.

The Acidity of Cranberry Bogs.

Cranberries thrive on a wide variation of soil. It is generally believed that this plant requires an acid soil, and yet, there are several growers using lime on cranberry bogs, and claim good results. Preliminary tests show that the lime requirement of cranberry soils in New Jersey varies from approximately 1,000 lbs. calcium oxide in white sand soils, to 8,000 to 10,000 lbs. calcium oxide in muck soils. Preliminary tests have been conducted this year to study the adaptation of cranberries to soils having varying amounts of acidity. The writer believes that this may furnish some valuable information regarding the adaptation of different varieties to cranberry soils as they exist. It is hoped to learn the degree of acidity in which cranberries thrive best. The test referred to also includes the use of finely powdered copper sulphate and manganese sulphate. The former, used extensively in spray mixtures, is believed to act as a stimulant and at the same time cause root injury. The latter element, manganese, supplied in the form of sulphate, is believed to be used in a small degree by the plant as a food. This experiment is only preliminary in nature and very small plots, one-hundredth of an acre, have been used. The plan follows:

No. of Plot.	Treatment.	No. of Plot.	Treatment.
1	Check.	16	Check.
2	.125 lbs. Copper Sulphate.	17	2 lbs. Sulphur.
3	Check.	18	4 lbs. Sulphur.
4	.25 lbs. Copper Sulphate.	19	5 lbs. Ground Limestone.
5	Check.	20	10 lbs. Ground Limestone.
6	.500 lbs. Copper Sulphate.	21	Check.
7	.5 lbs. Manganese Sulphate.	22	Check.
8	1.0 lbs. Manganese Sulphate.	23	20 lbs. Ground Limestone.
9	Check.	24	40 lbs. Ground Limestone.
10	Check.	25	2.5 lbs. Ground Burned Lime.
11	2 lbs. Manganese Sulphate.	26	5.0 lbs. Ground Burned Lime.
12	4 lbs. Manganese Sulphate.	27	Check.
13	.5 lbs. Sulphur.	28	Check.
14	1.0 lbs. Sulphur.	29	10 lbs. Ground Burned Lime.
15	Check.	30	20 lbs. Ground Burned Lime.

This work is being conducted on the two most common types of soil. Applications were first made last spring and to date there appears no change in growth.

Experiments With Fertilizers on Newly Set Bogs.

In the spring of 1913, Mr. A. D. Clarkson, of Pennington, N. J., wrote the Experiment Station regarding co-operative experimental work and offered the use of his cranberry bogs located about one and one-half miles from New Gretna in Burlington County for experimental purposes. Upon inspection the bogs were found to be in poor condition and it was not considered wise to run any extensive experiments. One newly set bog, however, had been carefully turfed and set the previous spring. The condition of this bog warranted experimental work and ten one-twentieth acre plots (33 x 66) were laid out and fertilized the twelfth of June, 1913, as follows:

No. 1—25 lbs. acid phosphate, 10 lbs. muriate of potash; No. 2—check, no fertilizer; No. 3—25 lbs. acid phosphate, 10 lbs. muriate of potash; No. 4—25 lbs. acid phosphate, 10 lbs. ammonium sulphate; No. 5—25 lbs. acid phosphate, 10 lbs. ammonium sulphate; No. 6—check, no fertilizer; No. 7—10 lbs. muriate of potash, 10 lbs. ammonium sulphate; No. 8—10 lbs. muriate of potash, 10 lbs. ammonium phosphate; No. 9—25 lbs. acid phosphate, 10 lbs. ammonium sulphate, 10 lbs. muriate of potash; No. 10—25 lbs. acid phosphate, 10 lbs. ammonium sulphate, 10 lbs. muriate of potash.

It is rather difficult to give a clear and well defined description of this bog. It consisted approximately of three acres without any systematic method of flowing. The natural drainage water of the surrounding country was depended upon for winter flooding. It received no artificial irrigation. The soil consisted of a layer of fine muck varying from three to six inches deep underlaid by sand varying greatly in thickness, which in turn was underlaid by a fine white gravel. The muck was well decomposed having little if any fibrous material or roots in it which may help to account for a greater amount of soil moisture than is commonly found in similar bogs in the same locality.

In the fall of 1913 plots 1 and 3, 7 and 8, and 9 and 10 had made good growth. The runners were long, numerous and many had already taken root. Plots 4 and 5 had not made such good growth and an occasional vine appeared weakened. The check plots had grown normally but showed less vigor than expected and noted especially in plots 1 and 3. The gates were closed about the middle of November and the bog was entirely flowed on December first.

The water was drawn from the bogs during the last week in May, 1914. At this time the vines appeared healthy. Observations made on June 19th showed occasional dead vines throughout the fertilized plots. Upon examination some vines were found to have been killed by the tramping of deer. No other evidence of injury could be located. The application of fertilizer were again made on the same plots. Subsequent observations showed a healthy condition, good growth and the proper number and distribution of fruit buds. This growth continued, according to Mr. U. J. Allen, Manager, until shortly after a heavy rain which occurred during the latter part of the second week in August. Mr. Allen's observations a week after the rain showed the vines beginning to turn brown. The runners and new growth were first affected.

Personal observation made September 16th showed that the vines on plots 7-10 inclusive had died. The greater number of vines in plots 1 and 3 and 4 and 5, were also dead but a few still remained alive. These were weak and had lost most of their leaves. Even in the case of those plots resetting will be necessary. So far as observations go, no injury of any description other than the fertilizer injury, contributed to this condition. There was no evidence of toad-bugs, girdle-worms, root-worms, or fire-worm injury.

It is believed by the writer that this fertilizer injury was caused by a lack of proper drainage and irrigation. This bog was dependent entirely upon the surrounding country for its irrigation, which this year was very limited, on account of the dry season. The fertilizer applied in June undoubtedly remained in the soil or on the top of it until the slight rain referred to when it was dissolved and carried into the soil water. This, however, made a solution too concentrated so that the plants were unable to get the food contained in it. Had there been sufficient rain during the season to properly irrigate this bog, or if the bog had been equipped with an adequate reservoir for irrigation, it is believed by the writer that the loss of vine would not have occurred.

REPORT

OF THE

Department of Soil Chemistry and Bacteriology

OF THE

New Jersey Agricultural College Experiment Station

New Brunswick, N. J.

BY

JACOB G. LIPMAN, PH.D.
AUGUSTINE W. BLAIR, A.M.

FOR THE YEAR ENDING
JUNE 30, 1920

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Report of the Department of Soil Chemistry and Bacteriology

JACOB G. LIPMAN
AUGUSTINE W. BLAIR

THE INFLUENCE OF THE MECHANICAL COMPOSITION OF THE SOIL ON THE AVAILABILITY OF NITRATE OF SODA AND DRIED BLOOD

The experiment was planned to determine the relative availability of nitrate nitrogen and organic nitrogen when the two are used in soils varying in mechanical composition. The work is being continued over a period of years in order that data may be accumulated with reference to the residual effects of these fertilizer materials. Barley has been grown for the first crop and with one exception, buckwheat for the second crop. The crop is harvested at maturity and grain and straw saved together and reported as dry matter.

Figure 1 indicates the arrangement of the cylinders with reference to the various dilutions, and the nitrogen treatments for the different series.

All cylinders receive 20 gm. of acid phosphate, 5 gm. of muriate of potash, 5 gm. of sulfate of potash, 38 gm. of ground limestone and 2 gm. of magnesium carbonate, annually, at the time of planting the first crop. The nitrogenous fertilizers also are applied at this time. No additional fertilizer application is made for the second crop, which is planted immediately after the first crop is harvested.

Barley, 1919

Following the residual crop of buckwheat in 1918 the cylinders were seeded to a cover crop of rye. The rye made fair growth during the early spring of 1919 and was 2 to 6 inches high at the time it was turned under on April 8. The rye was best on the loam-soil cylinders and those containing the higher percentages of loam-soil.

The ground was then prepared, fertilizers applied as already indicated and beardless barley planted in each cylinder. A fair crop was harvested July 5, and this was dried, the weights recorded and samples prepared for analysis. The analytical results are presented in table 1.

Series	Arrangement of Cylinders	Soil	Fertilizer Treatment
A....	① ② ③ ④ ⑤ ⑥	Shale Soil	1, 2, Nothing. 3, 4, 10 gm. nitrate soda. 5, 6, dried blood equivalent to 10 gm. nitrate of soda.
B....	① ② ③ ④ ⑤ ⑥	10% sand	"
C....	① ② ③ ④ ⑤ ⑥	20% "	"
D....	① ② ③ ④ ⑤ ⑥	30% "	"
E....	① ② ③ ④ ⑤ ⑥	40% "	"
F....	① ② ③ ④ ⑤ ⑥	50% "	"
G....	① ② ③ ④ ⑤ ⑥	70% "	"
H....	① ② ③ ④ ⑤ ⑥	80% "	"
I....	① ② ③ ④ ⑤ ⑥	90% "	"
J....	① ② ③ ④ ⑤ ⑥	100% "	"

Fig. 1. Plan of Experiment.

TABLE 1

FIRST CROP, BARLEY, 1919

Series		Nitrogen Applied	DRY MATTER		Nitrogen	NITROGEN			Nitrogen Recovered	Relative Availability
			Per Cylinder	Average		Per Cylinder	Average	Increase Over Check		
		gm.	gm.	gm.	per cent	gm.	gm.	gm.	per cent	
	1	....	46.0	....	1.129	0.519	....	....	....	....
	2	Nothing	35.2	40.60	1.209	0.426	0.472	....	....	....
A	3	1.54	116.5	....	1.129	1.315	....	....	....	....
	4	....	116.0	116.25	1.077	1.249	1.282	0.810	52.59	100.00
	5	....	93.7	....	1.216	1.139	....	....	....	....
	6	1.54	86.4	90.05	1.228	1.061	1.100	0.628	40.78	77.54
	1	....	49.2	....	1.307	0.643	....	....	....	....
	2	Nothing	33.5	41.35	1.156	0.387	0.515	....	....	....
B	3	....	96.6	....	1.176	1.136	....	....	....	....
	4	1.54	117.2	106.90	0.998	1.170	1.158	0.643	41.75	100.00
	5	....	85.2	....	1.137	0.969	....	....	....	....
	6	1.54	85.2	85.20	0.840	0.716	0.842	0.327	21.23	50.86
	1	....	30.8	....	1.188	0.366	....	....	....	....
	2	Nothing	24.6	27.70	1.275	0.314	0.340	....	....	....
C	3	....	114.6	....	1.010	1.157	....	....	....	....
	4	1.54	109.0	111.80	1.069	1.165	1.161	0.821	53.31	100.00
	5	....	81.8	....	1.137	0.930	....	....	....	....
	6	1.54	79.8	80.80	1.109	0.885	0.907	0.567	36.83	69.06
	1	....	31.7	....	1.208	0.383	....	....	....	....
	2	Nothing	38.0	34.85	1.168	0.444	0.413	....	....	....
D	3	....	118.8	....	1.156	1.373	....	....	....	....
	4	1.54	117.2	118.00	1.069	1.253	1.313	0.900	58.44	100.00
	5	....	76.6	....	1.137	0.871	....	....	....	....
	6	1.54	92.0	84.30	1.176	1.082	0.976	0.563	36.56	62.56
	1	....	13.4	....	1.295	0.174	....	....	....	....
	2	Nothing	29.7	21.55	1.196	0.355	0.264	....	....	....
E	3	....	107.6	....	1.196	1.287	....	....	....	....
	4	1.54	106.2	106.90	1.176	1.249	1.268	1.004	65.19	100.00
	5	....	86.0	....	1.109	0.954	....	....	....	....
	6	1.54	82.7	84.35	1.168	0.966	0.960	0.696	45.19	69.32

TABLE 1—(Continued)

FIRST CROP, BARLEY, 1919

Series		Nitrogen Applied	DRY MATTER Per Cylinder	DRY MATTER Average	Nitrogen	NITROGEN Per Cylinder	NITROGEN Average	NITROGEN Increase Over Check	Nitrogen Recovered	Relative Availability
		gm.	gm.	gm.	per cent	gm.	gm.	gm.	per cent	
F	1	....	24.2	....	1.156	0.280	....	....	....	....
	2	Nothing	30.6	27.40	1.295	0.396	0.338	....	....	....
	3	....	109.7	....	1.156	1.268	....	....	....	....
	4	1.54	63.5	86.60	1.148	0.729	0.998	0.660	42.86	100.00
	5	....	79.5	....	1.275	1.014	....	....	....	....
	6	1.54	84.0	81.75	1.038	0.872	0.943	0.605	39.28	91.67
G	1	....	19.7	....	1.057	0.208	....	....	....	....
	2	Nothing	22.2	20.95	1.188	0.264	0.236	....	....	....
	3	....	103.5	....	1.307	1.353	....	....	....	....
	4	1.54	88.2	95.85	1.010	0.891	1.122	0.886	57.53	100.00
	5	....	64.6	....	1.137	0.735	....	....	....	....
	6	1.54	63.7	64.15	1.129	0.719	0.727	0.491	31.88	55.41
H	1	....	22.7	....	1.188	0.270	....	....	....	....
	2	Nothing	18.5	20.60	1.188	0.220	0.245	....	....	....
	3	....	79.1	....	1.197	0.947	....	....	....	....
	4	1.54	99.2	89.15	1.216	1.206	1.076	0.831	53.96	100.00
	5	....	75.0	....	1.188	0.891	....	....	....	....
	6	1.54	65.0	70.00	1.228	0.798	0.844	0.599	38.90	72.08
I	1	....	13.3	....	1.129	0.150	....	....	....	....
	2	Nothing	18.4	15.85	1.148	0.211	0.180	....	....	....
	3	....	67.5	....	1.156	0.780	....	....	....	....
	4	1.54	51.8	59.65	1.137	0.589	0.684	0.504	32.73	100.00
	5	....	49.0	....	1.069	0.524	....	....	....	....
	6	1.54	47.5	48.25	1.069	0.508	0.516	0.336	21.82	66.67
J	1	....	7.5	....	1.168	0.088	....	....	....	....
	2	Nothing	5.5	6.50	1.215	0.067	0.077	....	....	....
	3	....	14.0	....	1.453	0.203	....	....	....	....
	4	1.54	12.1	13.05	1.366	0.165	0.184	0.107	6.95	100.00
	5	....	42.7	....	1.188	0.507	....	....	....	....
	6	1.54	28.0	35.35	1.089	0.305	0.406	0.329	21.36	307.34
AVERAGE			Check	25.74	1.193	0.308	....	....	....	....
			NaNO$_3$ ...	90.41	1.161	1.025	....	0.717	46.53	....
			Dr. Blood.	72.42	1.133	0.822	....	0.514	33.38	....

As in previous years, a larger crop was secured with nitrate of soda as a source of nitrogen than with dried blood in all series except the pure sand series. The highest average yield with the nitrate was secured in the 30 per cent sand series, and this was followed closely by the loam soil and the 20 per cent sand series. For convenience of comparison the average yields of barley (dry matter) for the three treatments, covering the last 5 years are reported in table 2.

TABLE 2.

AVERAGE YIELD OF BARLEY (DRY MATTER) 1915-1919

	1915	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	28.8	27.6	37.2	37.5	25.7
Nitrate of Soda ...	104.9	127.5	134.1	138.3	90.4
Dried Blood	87.7	94.0	83.1	92.9	72.4

It is significant that with 40 per cent sand the yield on the nitrate cylinders is only about 10 gm. less than the yield on the loam soil. With 90 per cent sand the yield is only about half as much as was obtained on the corresponding cylinders with 40 per cent sand.

Percentage of Nitrogen in Dry Matter and Total Nitrogen Recovered

Slight differences are noted in the percentage of nitrogen in the dry matter, but these are not especially significant.

The total yield of nitrogen usually varies with the yield of dry matter. It sometimes happens, however, that a low yield of dry matter shows a high percentage of nitrogen. This is true of series J, where there was an average yield of 13 gm. of dry matter showing 1.45 and 1.37 per cent of nitrogen in the two samples. The total yield of nitrogen recovered under the three treatments for the years 1915 to 1919 is shown in table 3.

The check cylinder gives, on an average, a yield of 0.3 to 0.4 gm., the nitrate of soda cylinder a yield of 1 gm. to 1.3 gm., and the dried-blood cylinder a yield of 0.8 to about 1.0 gm.

Percentage of Nitrogen Recovered

In calculating the percentage of nitrogen recovered it is assumed that the difference between the amount of nitrogen found in the crops from the check cylinders and that from the nitrogen-treated cylinders represents the amount of nitrogen which the latter were able to secure from the applied fertilizers. In practice this can be only approximately correct, but it serves as a method of comparing the amount of nitrogen which the crop is able to win back when different materials are used.

TABLE 3

YIELD OF NITROGEN, 1915-1919

	1915	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	0.311	0.318	0.412	0.404	0.308
Nitrate of Soda ...	1.156	1.252	1.344	1.234	1.025
Dried Blood	0.977	0.953	0.889	0.927	0.822

From an application of 1.54 gm. of nitrogen in the form of nitrate of soda and dried blood, the amount that was recovered in the barley for the ten series has been calculated. These figures are shown in the column, "Per cent of Nitrogen recovered," table 1.

For nitrate of soda a recovery of 65.19 per cent was obtained with the 40 per cent sand mixture, and 58.44 per cent with the 30 per cent sand mixture. The lowest recovery from nitrate of soda was 6.95 per cent in the all-sand cylinders.

In this connection it may be pointed out that this is the only case where the recovery from blood exceeded the recovery from nitrate of soda.

The highest recovery from dried blood was 45.19 per cent, also with the 40 per cent sand mixture, and the lowest 21.36 per cent with sand. The average recovery from nitrate of soda was 46.53 per cent and from dried blood 33.38 per cent.

The average recoveries for the last 5 years are shown in table 4.

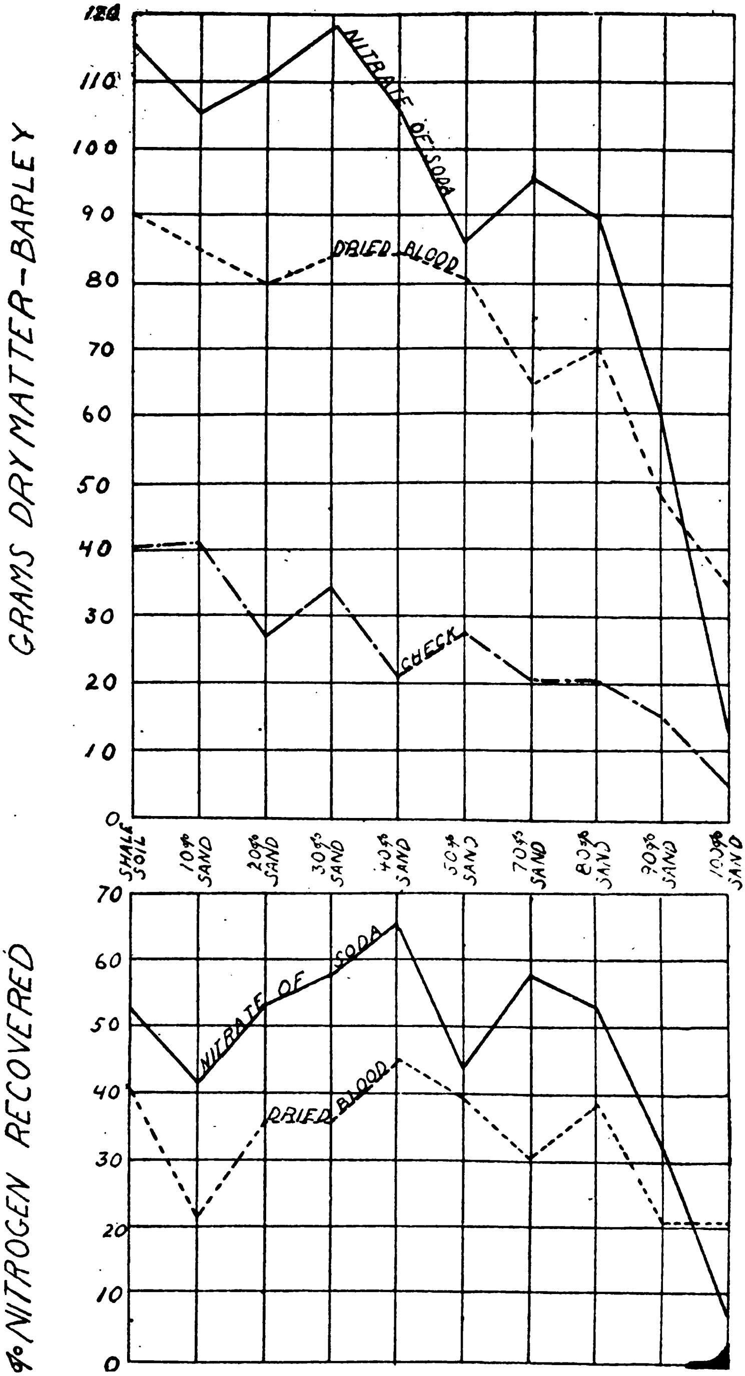

FIG. 2. CURVES SHOWING WEIGHT OF DRY MATTER AND PERCENTAGE OF NITROGEN RECOVERED IN FIRST CROP—BARLEY, 1919

The figures expressing the relative availability of the two materials are shown in the last columns of table 1.

If we take 100 as representing the availability of nitrate of soda, then the availability of dried blood for the loam soil will be 77.54; in the same way the relative availability of blood with the 50 per cent sand loam-soil mixture is 91.67, and for the all-sand series it is 307.34.

Thus it is shown that for the loam-soil and for all dilutions of this soil up to and including 90 per cent sand, nitrate of soda has a higher availability than dried blood. In the all-sand series the blood shows more lasting properties than the nitrate.

The yield of dry matter (barley) and the percentage of nitrogen recovered are indicated by graphs in figure 2.

TABLE 4

AVERAGE RECOVERY OF NITROGEN FROM NITRATE OF SODA AND DRIED BLOOD, 1915-1919

	1915	1916	1917	1918	1919
	per cent	per cent	per cent	per cent	per cent
Nitrate of Soda ...	54.89	60.64	60.53	53.90	46.53
Dried Blood	43.28	41.23	30.98	33.97	33.38

Buckwheat-Residual Crop, 1919

Buckwheat is seeded as a second crop in order that any nitrogen which the first crop may have left may be used. No fertilizers are applied for this second crop.

The buckwheat was seeded July 12, about two days after the barley was harvested. On the sixteenth the grain was coming up uniformly in all cylinders. Growth was normal and on September 9 the crop was harvested and samples saved and prepared for analysis in the usual way. The analytical results together with a summary for the two crops are reported in table 5.

TABLE 5

Residual Crop of Buckwheat, 1919, and Summary for Both Crops

Series		DRY MATTER			NITROGEN				SUMMARY FOR BOTH CROPS				
		Per Cylinder	Average	Nitrogen	Per Cylinder	Average	Increase Over Check	Nitrogen Recovered	Total Dry Matter	Total Nitrogen	Nitrogen Increase Over Check	Nitrogen Recovered	Relative Availability
		gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	
A 1	NO NITROGEN APPLIED FOR RESIDUAL CROP	33.0	.....	0.845	.279	.....	......	.....	......	......	......	.....	......
2		39.1	36.05	1.133	.443	.3610	......	.....	76.65	.8330	......	.....	......
3		37.5	.....	0.949	.356	.....	......	.....	......	......	......	.....	......
4		34.5	36.00	1.133	.391	.3735	.0125	0.81	152.25	1.6555	0.8225	53.41	100.00
5		58.3	.....	1.114	.649	.....	......	.....	......	......	......	.....	......
6		52.3	55.30	1.056	.552	.6005	.2395	15.55	145.35	1.7005	0.8675	56.33	105.47
B 1		45.5	.....	1.123	.511	.....	......	.....	......	......	......	.....	......
2		36.0	40.75	1.114	.401	.4560	......	.....	82.10	.9710	......	.....	......
3		36.0	.....	1.160	.418	.....	......	.....	......	......	......	.....	......
4		50.6	43.30	1.210	.612	.5150	.0590	3.83	150.20	1.6730	0.7020	45.59	100.00
5		42.2	.....	1.075	.454	.....	......	.....	......	......	......	.....	......
6		50.7	46.45	1.114	.565	.5095	.0535	3.47	131.65	1.3515	0.3805	24.71	54.20
C 1		33.7	.....	1.152	.388	.....	......	.....	......	......	......	.....	......
2		36.3	35.00	1.172	.425	.4065	......	.....	62.70	.7465	......	.....	......
3		40.5	.....	1.114	.451	.....	......	.....	......	......	......	.....	......
4		44.7	42.60	1.160	.519	.4850	.0785	5.10	154.40	1.6460	0.8995	58.41	100.00
5		34.5	.....	1.152	.397	.....	......	.....	......	......	......	.....	......
6		45.3	39.90	1.152	.522	.4595	.0530	3.44	120.70	1.3665	0.6200	40.26	68.93
D 1		32.0	.....	1.179	.377	.....	......	.....	......	......	......	.....	......
2		35.8	33.90	1.198	.429	.4030	......	.....	68.75	.8160	......	.....	......
3		40.5	.....	1.123	.455	.....	......	.....	......	......	......	.....	......
4		47.0	43.75	1.191	.560	.5075	.1045	6.79	161.75	1.8205	1.0045	65.23	100.00
5		38.2	.....	1.152	.440	.....	......	.....	......	......	......	.....	......
6		49.7	43.95	1.114	.554	.4970	.0940	6.10	128.25	1.4730	0.6570	42.66	65.41
E 1		40.2	.....	1.275	.513	.....	......	.....	......	......	......	.....	......
2		33.5	36.85	1.133	.380	.4465	......	.....	58.40	.7105	......	.....	......
3		37.4	.....	1.248	.467	.....	......	.....	......	......	......	.....	......
4		39.5	38.45	1.248	.493	.4800	.0335	2.18	145.35	1.7480	1.0375	67.37	100.00
5		40.5	.....	1.172	.475	.....	......	.....	......	......	......	.....	......
6		36.7	38.60	1.287	.472	.4735	.0270	1.75	122.95	1.4335	0.7230	46.95	69.69

TABLE 5—(Continued)

Residual Crop of Buckwheat, 1919, and Summary for Both Crops

NO NITROGEN APPLIED FOR RESIDUAL CROP

Series		Dry Matter			Nitrogen				Summary for Both Crops				
		Per Cylinder	Average	Nitrogen	Per Cylinder	Average	Increase Over Check	Nitrogen Recovered	Total Dry Matter	Total Nitrogen	Nitrogen Increase Over Check	Nitrogen Recovered	Relative Availability
		gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	gm.	gm.	gm.	p. c.	
F	1	45.5	.....	1.114	.507	.....	.....	.....	.....	.....	.....	.....	.....
	2	36.2	40.85	1.248	.452	.4795	.....	.....	68.25	.8175	.....	.....	.....
	3	28.0	.....	1.191	.333	.....	.....	.....	.....	.....	.....	.....	.....
	4	42.2	35.10	1.210	.511	.4220	.....	.....	121.70	1.4200	0.6025	39.12	100.00
	5	39.7	.....	1.198	.476	.....	.....	.....	.....	.....	.....	.....	.....
	6	34.7	37.20	1.123	.390	.4330	.....	.....	118.95	1.3760	0.5585	36.27	92.70
G	1	22.5	.....	1.191	.268	.....	.....	.....	.....	.....	.....	.....	.....
	2	21.0	21.75	1.268	.266	.2670	.....	.....	42.70	.5030	.....	.....	.....
	3	24.7	.....	1.191	.294	.....	.....	.....	.....	.....	.....	.....	.....
	4	34.2	29.45	1.248	.427	.3605	.0935	6.07	125.30	1.4825	0.9795	63.60	100.00
	5	30.5	.....	1.191	.363	.....	.....	.....	.....	.....	.....	.....	.....
	6	17.4	23.95	1.218	.212	.2875	.0205	1.33	88.10	1.0145	0.5115	33.21	52.22
H	1	19.9	.....	1.160	.231	.....	.....	.....	.....	.....	.....	.....	.....
	2	17.0	18.45	1.218	.207	.2190	.....	.....	39.05	.4640	.....	.....	.....
	3	9.0	.....	1.160	.104	.....	.....	.....	.....	.....	.....	.....	.....
	4	17.5	13.25	1.306	.229	.1665	.....	.....	102.40	1.2425	0.7785	50.57	100.00
	5	18.0	.....	1.218	.219	.....	.....	.....	.....	.....	.....	.....	.....
	6	14.3	16.15	1.191	.170	.1945	.....	.....	86.15	1.0385	0.5745	37.31	73.80
I	1	4.0	.....	1.256	.050	.....	.....	.....	.....	.....	.....	.....	.....
	2	7.2	5.60	1.287	.093	.0715	.....	.....	21.45	.2515	.....	.....	.....
	3	6.5	.....	1.248	.081	.....	.....	.....	.....	.....	.....	.....	.....
	4	7.0	6.75	1.314	.092	.0865	.0150	0.97	66.40	.7705	0.5190	33.70	100.00
	5	17.0	.....	1.371	.233	.....	.....	.....	.....	.....	.....	.....	.....
	6	15.5	16.25	1.371	.213	.2230	.1515	9.80	64.50	.7390	0.4875	31.66	93.95
J	1	2.0	.....	1.498	.030	.....	.....	.....	.....	.....	.....	.....	.....
	2	3.2	2.60	1.421	.045	.0375	.....	.....	9.10	.1145	.....	.....	.....
	3	2.5	.....	1.506	.037	.....	.....	.....	.....	.....	.....	.....	.....
	4	1.5	2.00	1.325	.020	.0285	.....	.....	15.05	.2125	0.0980	6.36	100.00
	5	10.0	.....	1.371	.137	.....	.....	.....	.....	.....	.....	.....	.....
	6	5.0	7.50	1.867	.093	.1150	.0775	5.03	42.85	.5210	0.4065	26.40	414.80
AVERAGE	1	.....	27.18	1.199	.....	.3148	.....	.....	52.92	0.6228	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	29.07	1.211	.....	.3425	.....	.....	119.48	1.3671	.7444	48.34	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5	.....	32.53	1.225	.....	.3793	.....	.....	104.95	1.2014	.5787	37.58	.....
	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

From this table it will be observed that in the majority of cases the yield was larger with dried blood than with nitrate of soda. This is an indication that the nitrate was more completely used by the first crop than the blood; or to state the matter another way, the blood has greater residual effects than the nitrate. The yields are shown by graphs in figure 3.

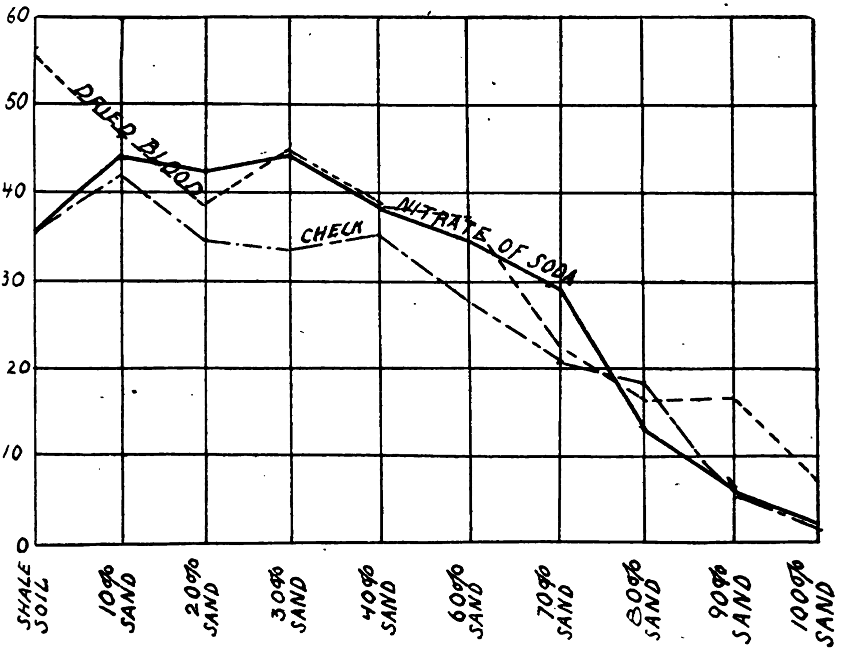

Fig. 3. Curves Showing Grams of Dry Matter in Second Crop—Buckwheat, 1919

This greater residual effect is not sufficient, however, to offset the initial effect of the nitrate on the first crop and, as has been pointed out in previous reports, this greater initial influence of the nitrate serves to place it in the first rank when the two crops are considered together. This is shown in the last part of table 5.

The average yields for the residual crops for the five years, 1915-1919, are shown in table 6.

TABLE 6

AVERAGE YIELD OF BUCKWHEAT-RESIDUAL CROP, 1915-1919

	1915*	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	21.32	25.83	32.31	32.0	27.18
Nitrate of Soda ..	22.58	23.78	32.70	29.0	29.07
Dried Blood	28.22	32.70	44.24	45.1	32.53

* Kafir Corn.

It is of interest to compare these figures with the figures showing the combined yields of the two crops for the same period. These are shown in table 7.

TABLE 7

COMBINED YIELDS OF BARLEY AND BUCKWHEAT (DRY MATTER), 1915-1919

	1915	1916	1917	1918	1919
	gm.	gm.	gm.	gm.	gm.
Check	50.11	53.45	68.92	69.62	52.92
Nitrate of Soda ..	127.44	151.30	166.79	167.33	119.48
Dried Blood	115.90	126.70	124.75	138.04	104.95

This table emphasizes what has already been mentioned, namely, that when the two crops are combined the yield with nitrate of soda exceeds the yield with dried blood, even though equivalent amounts of nitrogen are used. The greater effectiveness of the nitrate during the early life of the plant has been suggested as an explanation for this pronounced difference. The rapid development of the nitrate-treated plants, with large, well-filled heads and broad leaves, suggests this explanation. Figures 4, 5 and 6 show graphically the comparative yields of the two crops on the shale soil, the 40 per cent sand mixture, and the 80 per cent sand mixture, with nitrate of soda, dried blood and no nitrogen (check), for the years 1912-1919.

It will be noted that for the shale soil the yield with dried blood exceeds the yield with nitrate of soda in three out of the eight years; for the 40 per cent sand mixture the yield with nitrate of soda exceeds the yield with blood throughout the eight years; for the 80 per cent sand mixture the yield with blood exceeds the yield with nitrate in two out of the eight years. It is significant that the yield for the 80 per cent sand mixture should so consistently run higher with nitrate than with blood. It would be expected that with such a high percentage of sand the loss of nitrates through leaching would be excessive. It is possible that two factors may combine to reduce this loss; the barley, once it is well-started, makes a rapid growth and thus uses the nitrates rapidly, and the second crop, which is always grown, helps to conserve any available nitrogen not utilized by the first crop.

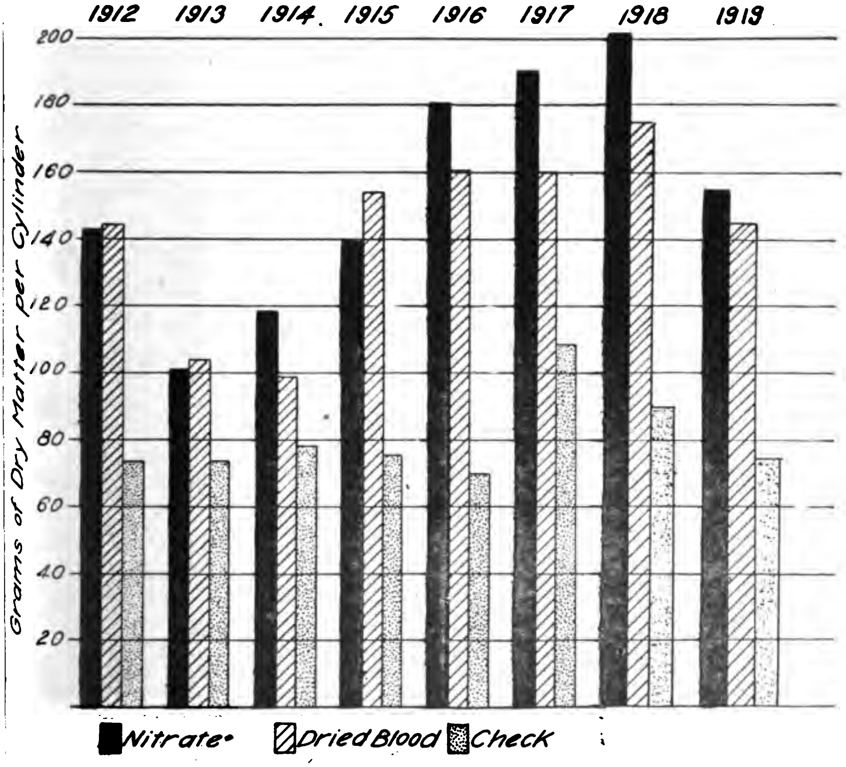

FIG. 4. COMPARATIVE YIELD OF DRY MATTER, TWO CROPS EACH YEAR, FROM SHALE SOIL (PENN LOAM) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK (NO NITROGEN), 1912-1919

These results indicate that in some cases, at least, the ease with which nitrates are lost has been over-emphasized.

Percentage of Nitrogen Recovered-Residual Crop

The recovery of nitrogen through the residual crop was small. Indeed in some cases there was no recovery above the amount recovered through the crops on the check cylinders—that is, there was no recovery from applied fertilizers. In series B, C, D, E and G the recovery with nitrate was greater than with dried blood. This is the reverse of what has usually been true for the residual crop. The highest recovery for this crop was 15.55 with dried blood, in series A.

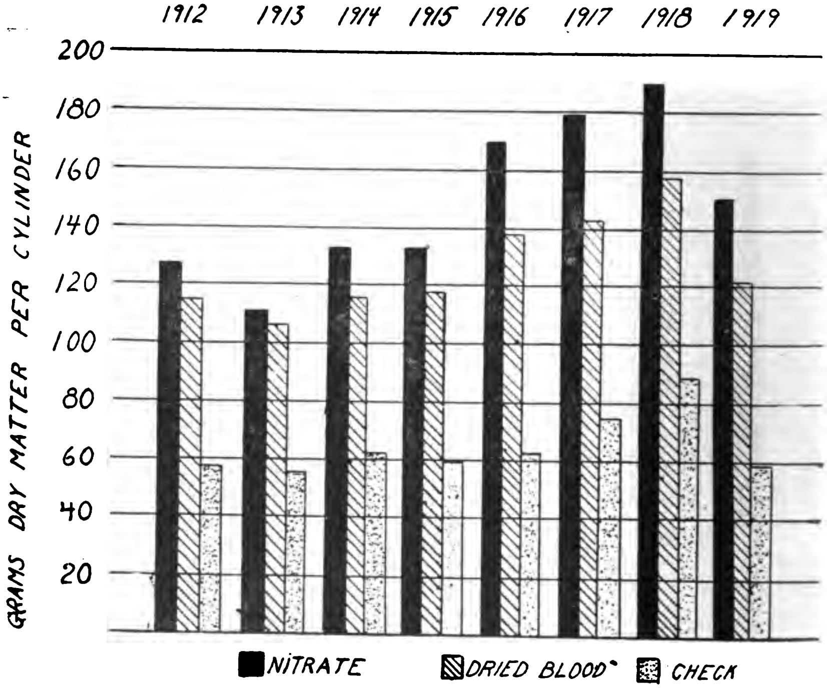

FIG. 5. COMPARATIVE YIELD OF DRY MATTER, TWO CROPS EACH YEAR, FROM THE 40 PER CENT SAND MIXTURE (SERIES E) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK, 1912-1919

Summary

When barley was grown on loam soil and on various dilutions of this loam with sand, nitrate of soda gave a larger yield of dry matter and a higher percentage of nitrogen recovered, than an equivalent amount of dried blood, in all cases except the all-sand series.

The average recovery with nitrate, for all series, was 46.53 per cent, and for dried blood 33.38 per cent.

The average for the past five years is: nitrate of soda, 55.3 per cent; dried blood, 36.6 per cent.

With the residual crop—buckwheat—grown without any further fertilizer treatment, there was very little recovery of nitrogen from either nitrate of soda or dried blood.

When the results for the two crops are combined the average recoveries stand:

Nitrate of Soda	47.34 per cent
Dried Blood	37.58 per cent

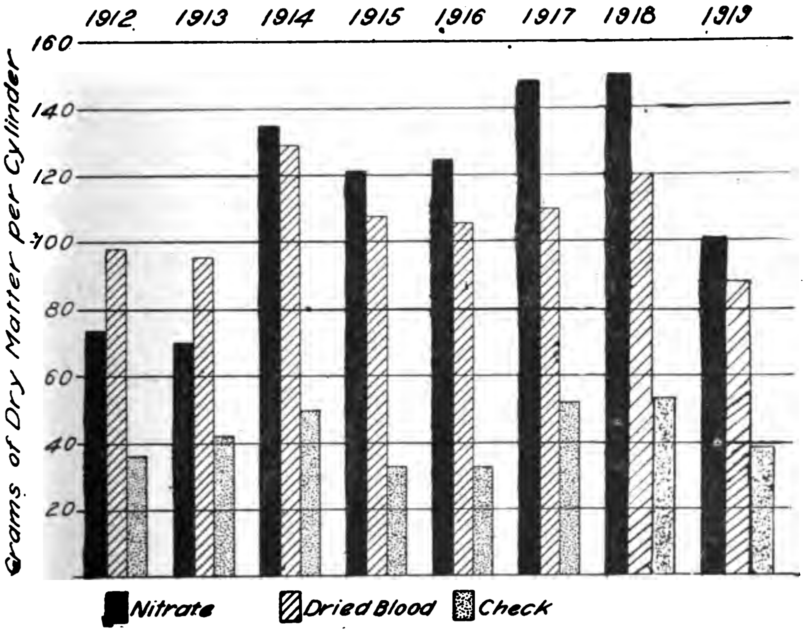

FIG. 6. COMPARATIVE YIELDS OF DRY MATTER, TWO CROPS EACH YEAR, FROM THE 80 PER CENT SAND MIXTURE (SERIES H) WITH NITRATE OF SODA, DRIED BLOOD AND CHECK, 1912-1919

The average combined recoveries for the last five years are:

Nitrate of Soda	57.02 per cent
Dried Blood	49.60 per cent

With the soil under consideration, nitrate gives only a slight *residual* recovery of nitrogen, but its *initial* effect—that is the effect on the first crop—is sufficiently above the initial effect of dried blood to give it a higher standing than the latter, when the results for the two crops are combined.

THE INFLUENCE OF LIME ON THE YIELD AND NITROGEN CONTENT OF SOYBEANS

Since 1913 this department has been conducting experiments with different varieties of soybeans on limed and unlimed plots.

The latest published account of this work appeared in the annual report for 1918. The results for 1918 and 1919 have now been tabulated and are herewith reported.

Plan of Experiment

The experiment is carried out on small plots varying in size from 1-80 to 1-40 acre. The soil is a loam of fair quality, though naturally deficient in nitrogen. To certain of the plots ground limestone was applied in 1908, at the rate of 1 ton per acre. Other plots received no lime. The lime treatment was repeated in 1913 and again in 1918, this time at the rate of 2 tons per acre. All plots receive annual applications of acid phosphate and muriate of potash—the former at the rate of 400 to 600 pounds per acre and the latter at the rate of 100 to 200 pounds per acre. With one exception to be noted hereafter, nitrogenous fertilizers have not been applied. Lime requirement and nitrogen determinations have been made on samples of soil taken from these plots before the lime was applied in the spring of 1918. The results are as follows:

	Lime Requirement (Veitch Method)	Nitrogen
	pounds	per cent
Limed Plots	700	0.1055
Unlimed Plots	1,550	0.0900

It will be noted that the soil from the limed plots shows a higher percentage of nitrogen than that from the unlimed plots. This is in accord with results secured on the same kind of soil when clover was seeded with timothy in a 5-year rotation of corn, oats, wheat, and timothy and clover, and just the opposite of results secured in the same rotation with the omission of the clover.

A record has also been made of the number of nodules found on a definite number of plants taken from limed and unlimed plots, for certain varieties.

The beans are allowed to stand and ripen on the vines and this means that at harvest time practically all leaves have fallen off.

TABLE 8

The Influence of Lime on the Yield and Nitrogen Content of Soybeans, 1918 (Calculated to the Acre Basis)

VARIETY	LIMED			UNLIMED			LIMED			UNLIMED			Total Nitrogen Recovered	
	D'y B'n	Nitrogen		D'y B'n	Nitrogen		D'y St'k	Nitrogen		D'y St'k	Nitrogen		Limed	Unlimed
	Bu.	Per ct.	Lbs.	Bu.	Per ct.	Lbs.	Lbs.	Per ct.	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.
Austin	21.3	6.18	79.10	9.6	5.91	34.16	1,720	0.66	11.27	934	0.68	6.38	90.37	40.54
Elton	20.9	7.46	93.40	11.2	6.52	43.81	1,364	0.96	13.03	760	0.77	5.83	106.43	49.64
Haberlandt	14.5	6.64	57.90	5.1	6.36	19.33	1,592	1.69	26.90	460	1.61	7.41	84.80	26.74
Manchu	19.5	6.01	70.20	10.1	5.52	33.34	896	*	......	648	*	......	70.20†	33.34†
Manhattan	14.1	6.60	55.97	6.1	6.05	22.02	1,040	0.88	9.15	488	0.70	3.43	65.12	25.45
Med-Yellow	20.0	6.06	72.72	11.9	5.54	39.45	1,488	0.83	12.40	848	0.72	6.11	85.12	45.56
Ohio 9035	17.5	6.45	67.60	7.3	5.86	25.55	1,344	1.33	17.88	764	1.02	7.79	85.48	33.34
Virginia	20.8	6.26	78.13	10.8	5.77	37.39	1,792	0.79	14.09	904	0.99	8.97	92.22	46.36
Average	18.6	6.46	71.88	9.0	5.94	31.88	1,405	1.00	14.96	726	0.92	6.56	87.08	38.23
Baird	12.9	7.07	54.58	These varieties were not represented by unlimed plots.			1,470	1.03	15.14	....	......	......	69.72	....
Cloud	19.5	5.94	69.50				1,968	0.62	12.16	....	......	......	81.66	....
Ebony	16.8	6.77	68.24				1,236	1.13	13.97	....	......	......	82.21	....
Edna	20.6	6.34	78.36				1,686	0.70	11.84	....	......	......	90.20	....
Guelph	16.2	6.25	60.56				1,353	0.85	11.53	....	......	......	72.09	....
Ito San	17.9	6.79	72.79				1,192	*	......	....	......	......	72.79†	....
Minn. No. 115	18.0	6.50	70.40				1,047	*	......	....	......	......	70.40†	....
Swan	19.1	6.34	72.78				1,604	1.03	16.52	....	......	......	89.30	....
Wilson	17.9	6.07	65.13				1,363	*	......	....	......	......	65.13†	....
Average	17.7	6.45	68.04				1,435	0.89	13.53	....	......	......	80.86	....

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* Nitrogen not determined.

† For beans only, omitted from average.

Results for 1918

The yields and analytical results for the different varieties are shown in table 8.

From the table it will be noted that in addition to the limed and unlimed series nine varieties were grown on limed plots and were not represented by corresponding unlimed plots.

Shelled Beans

The yield of dry shelled beans on the limed plots varies from about 13 to about 21 bushels, with an average of slightly more than 18 bushels per acre. The unlimed plots show an average of 9 bushels per acre.

The average nitrogen content of the beans from the limed plots is 6.46 per cent (maximum 7.46, minimum 6.01) and the average from the unlimed plots is 5.94 per cent.

The average amount of nitrogen recovered from the limed plots was 71.88 pounds (68.04 for the nine varieties not having corresponding limed plots) and 31.88 pounds for the unlimed plots. The highest individual yield was 93.4 pounds from Elton and the lowest 55.97 pounds from Manhattan.

Dry Stalks

The average yield of dry stalks from the limed plots of the first eight varieties was 1,405 pounds per acre and the average from the unlimed plots 726 pounds. The average nitrogen content of seven of these varieties from the limed plots was 1.00 per cent, and from the unlimed plots 0.92 per cent.

More than twice as much nitrogen was recovered through the stalks from the limed plots as from the unlimed plots.

The average total nitrogen—from beans and stalks—recovered from the limed plots was 87.08 pounds per acre and the average from the unlimed plots was 38.23 pounds per acre. The highest individual recovery was 106.43 pounds from Elton. It should be borne in mind that this does not represent the nitrogen of the leaves and roots.

Results for 1919

The results for 1919 are shown in table 9. They bear out, in a striking manner, the results of the preceding year, and also results secured in 1916 and 1917.

TABLE 9

The Influence of Lime on the Yield and Nitrogen Content of Soybeans, 1919 (Calculated to the Acre Basis)

VARIETY	LIMED			UNLIMED			LIMED			UNLIMED			Total Nitrogen Recovered	
	D'y B'n	Nitrogen		D'y B'n	Nitrogen		D'y St'k	Nitrogen		D'y St'k	Nitrogen		Limed	Unlimed
	Bu.	Per ct.	Lbs.	Bu.	Per ct.	Lbs.	Lbs.	Per ct.	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.
Baird	14.6	7.01	61.44	3.3	6.77	13.40	1,566	1.294	20.26	414	1.176	4.87	81.70	18.27
Ebony	19.4	6.71	78.07	1.4	6.88	5.78	1,254	0.978	12.26	168	1.085	1.82	90.33	7.60
Edna	22.4	6.36	85.52	0.5	6.29	1.89	1,794	0.868	15.57	210	1.274	2.68	101.09	4.57
Minn. No. 115	13.7	6.45	53.02	4.2	6.32	15.93	1,026	0.848	8.70	396	0.998	3.95	61.72	19.88
Swan	20.9	6.85	85.85	1.3	6.32	4.93	1,716	1.065	18.28	132	0.888	1.17	104.13	6.10
Wilson	19.5	5.99	70.07	1.1	5.40	3.56	1,656	0.840	13.91	138	0.947	1.31	83.98	4.87
Average	18.4	6.56	72.33	2.0	6.33	7.58	1,502	0.983	14.83	243	1.063	2.63	87.16	10.21
Austin	21.4	6.61	84.65	These varieties were not represented by unlimed plots.			1,428	0.959	13.70	....	......	......	98.35	....
Cloud	16.8	6.19	62.36				1,770	1.262	22.34	....	......	......	84.77	....
Elton	20.6	7.00	86.55				1,224	1.065	13.04	....	......	......	99.59	....
Haberlandt	19.3	6.82	78.94				1,674	1.105	18.50	....	......	......	97.44	....
Hahto	13.5	6.21	50.26				1,602	1.854	29.70	....	......	......	79.96	....
Ito San	11.2	6.77	45.47				918	1.767	16.20	....	......	......	61.67	....
Manchu	24.1	6.42	92.86				1,650	1.203	19.85	....	......	......	112.71	....
Manhattan	5.6*	6.83	22.93*				426*	0.959	4.09*	....	......	......	27.02*	....
Virginia	22.9	6.31	86.73				2,046	0.789	16.14	....	......	......	102.87	....
Average	18.7	6.57	73.48				1,539	1.220	18.68	....	......	......	92.17	....

* Omitted from average.

There is, however, this difference between results for this year and previous years; the unlimed plots are all the time becoming more acid, and on this account there is a marked falling off in the yield from these plots. On some of the plots the crop was almost an entire failure.

The average yield of shelled beans on the limed plots was about 18½ bushels per acre and on the unlimed plots only 2 bushels per acre. The average nitrogen content on the limed plots was 6.56 per cent and the average on the unlimed plots 6.33 per cent. Of the 6 varieties grown on limed and unlimed plots five show a higher percentage of nitrogen when grown on the limed plots than when grown on the unlimed plots. The average nitrogen recovered from the six limed plots was 72.33 pounds per acre as against 7.58 pounds for the corresponding unlimed plots. The figures for the nine varieties grown on limed plots only, check very closely with the figures for the limed section of the six varieties just considered.

Dry Stalks

The average yield of dry stalks from the limed section of the first six varieties was 1,502 pounds per acre and the average from the corresponding unlimed section 243 pounds. In this case the average percentage of nitrogen in samples from the unlimed section is slightly higher than the average in samples from the limed section. The average nitrogen recovered in the stalks stands 14.83 pounds per acre from the limed section and 2.63 pounds from the unlimed section.

The average total nitrogen recovered through beans and stalks is, for the limed section 87.16 pounds per acre and for the unlimed section 10.21 pounds. The average yield of nitrogen for the 9 varieties not having corresponding unlimed plots is 92.17 pounds per acre. It is thus shown there was nearly nine times as much nitrogen recovered through beans grown on limed plots as through those grown on unlimed plots.

Plate 1 shows Virginia soybeans grown on limed and unlimed plots in 1918. The yields from this variety are given in tables 8 and 9. Plate 2 shows beans growing on limed and unlimed plots in 1919. These two plots lie side by side and three varieties were grown on each plot. The photographs were made from the same relative position with reference to the three varieties.

The Influence of Lime on Nodule Formation

Note has been made in previous reports of the difference in the number of nodules on the roots of soybean plants grown on limed and unlimed plots. During the summer of 1919 further results were secured on this point and they are given here as confirming the earlier work.

When the plants were just coming into bloom twelve representative plants were removed from the limed and unlimed sections of the three plots on which the Baird, Swan and Wilson varieties had been planted. In removing the plants, care was taken to save as many of the nodules as possible. The nodules were counted and the tops and roots separated and dried. After drying, the samples were ground and analyzed for nitrogen. The results are shown in table 10.

TABLE 10

INFLUENCE OF LIME ON NODULE FORMATION

	DRY TOPS		DRY ROOTS			
	Nitrogen		Nitrogen		Number of Nodules per plant	
	Limed per cent	Unlimed per cent	Limed per cent	Unlimed per cent	Limed	Unlimed
Baird	3.83	3.60	2.08	1.83	106	16
Swan	3.75	3.25	1.60	1.53	129	3
Wilson	3.35	3.17	1.77	1.77	97	6

With reference to the tops it will be noted that without exception the samples from the limed plots show a higher percentage of nitrogen than those from the unlimed plots.

For the roots this is true for two of the varieties while for the third variety—Wilson—the percentage is the same for the limed and the unlimed sections. The plants on the unlimed section made a stunted growth and produced but few nodules, while those on the limed plots made a healthy growth and were abundantly supplied with nodules. The average number of nodules per plant for the latter was 110 and for the former was only 8 1-3.

It is of interest to note the high percentage of nitrogen in the tops from the limed section. Two tons of soybean hay analyzing as high as the sample represented by the Baird would mean more than 150 pounds of nitrogen per acre, exclusive of roots.

It is very evident that there is a close relationship between the reaction of the soil and the development of those organisms which cause nodule formation, and therefore between the reaction of the soil and nitrogen accumulation.

Summary

Several varieties of soybeans have been grown on limed and unlimed plots continuously since 1913.

The average yield on the limed plots for the seasons of 1918 and 1919 was a little over 18 bushels of shelled beans per acre. For the unlimed plots the average for 1918 was 9 bushels per acre and for 1919 only 2 bushels per acre.

The maximum yield for the limed plots was slightly over 21 bushels per acre in 1918 and nearly 23 bushels in 1919.

The average yield of dry stalks for the limed plots was close to ¾ ton per acre for both years, whereas the average yield for the unlimed plots was 726 pounds in 1918 and only 243 pounds in 1919.

The average percentage of nitrogen in the dry shelled beans was as follows:

	1918 per cent	1919 per cent
Limed	6.46	6.56
Unlimed	5.94	6.33

For both years the limed plots of the section having both limed and unlimed plots gave an average return of 87 pounds of nitrogen per acre exclusive of the nitrogen in roots and fallen leaves. The unlimed plots gave an average return of 38.2 pounds per acre in 1918 and 10.2 pounds in 1919.

When plants were taken up by the roots about the time they were beginning to bloom, there were, on the average, more than ten times as many nodules on plants from limed as from unlimed plots. These plants from the limed plots—both tops and roots—contained a higher percentage of nitrogen than plants from the corresponding unlimed plots.

Lime aids greatly in the accumulation of nitrogen through the use of leguminous plants.

THE INFLUENCE OF NITROGENOUS FERTILIZERS ON THE YIELD AND NITROGEN CONTENT OF SOYBEANS

It is generally believed that when leguminous crops are grown on properly inoculated soil that is not acid, they do not require nitrogeneous fertilizers.

TABLE 11

The Influence of a Nitrogenous Fertilizer on the Yield and Nitrogen Content of Soybeans

Fertilizer Treatment	Shelled Beans			Stalks			Total Nitrogen
	Beans	Nitrogen		Dry Matter	Nitrogen		
	bushels	per cent	pounds	pounds[1]	per cent	pounds	pounds
Ohio 9035—							
Nitrate of Soda	16.6	6.371	63.46	1068	1.578	16.85	80.31
Ammonium Sulfate	15.4	6.509	60.15	1038	1.124	11.67	71.82
No Nitrogen (check)	18.2	6.608	72.16	1296	1.282	16.62	88.78
Medium Yellow—							
Nitrate of Soda	22.7	6.186	84.25	1638	0.986	16.51	100.76
Calcium Cyanamid..	22.6	6.344	86.03	1614	0.927	14.96	100.99
No Nitrogen (check)	21.5	6.320	81.53	1488	1.144	17.03	98.56

In connection with the soybean experiments it seemed worth while to try out three nitrogenous materials to determine whether their use might in any way influence the yield or the nitrogen content of the dry matter.

The soil is the same as that described in the preceding report, and the lime, phosphate and potash treatment has been the same as that given the limed soybean plots already described.

The nitrogenous fertilizers were applied in the row, before planting, at the rate of 150 pounds of nitrate of soda per acre, and equivalent amounts of the ammonium sulfate and calcium cyanamid.

Two varieties of beans were planted; Ohio 9,035 on three plots, the treatments for which were nitrate of soda, ammonium sulfate and the check, or no nitrogen; and Medium Yellow on three other plots, the treatments for which were nitrate of soda, calcium cyanamid, and the check. The results of the test are given in table 11.

For Ohio 9035 the no-nitrogen plot gave the highest yield of beans and stalks and also the highest percentage of nitrogen in the shelled beans. From the check plot of this series there was recovered 88.78 pounds of nitrogen per acre, whereas from the nitrate of soda and ammonium sulfate plots the recoveries were 80.31 pounds and 71.82 pounds per acre, respectively.

For the Medium Yellow variety the yield of shelled beans on the check plot was slightly over 1 bushel per acre less than the yield on the two nitrogen-treated plots, but the percentage of nitrogen in the dry matter was sufficiently well maintained to bring the total nitrogen recovered to within about 2½ pounds of the amount recovered in the two nitrogen-treated plots. It is of interest to note that the average recovery of nitrogen through the crop on the three plots occupied by the Medium Yellow is 100 pounds per acre.

The work further confirms the general belief that legume crops, when properly inoculated, do not require nitrogenous fertilizers.

THE CONTINUOUS GROWING OF CORN WITH A LEGUME AND A NON-LEGUME GREEN MANURE CROP, 1919

This constitutes the twelfth report on this work. The results for the years 1908 to 1918 have appeared in earlier reports of the station. In this experiment a study is being made of the value of a legume green-manure crop as compared with a non-legume in the continuous growing of corn. On each section small amounts of cow manure are used for the purpose of inoculating the soil with decay organisms.

The soil is a gravelly loam which is deficient in nitrogen.

Plan of Experiment

The plots are 1-20 acre in size. Ground limestone was applied in 1908 when the work was started, and again in 1913 and 1918. Before planting the corn in 1919 acid phosphate and muriate of potash were applied broadcast at the rate of 300 and 100 pounds per acre, respectively. Nitrate of soda and ammonium sulfate also were applied, the combined application being equivalent to 160 pounds of nitrate of soda per acre. The special treatment for the two sections was as follows:

Legume Section

Plot 49—Corn followed by legume cover crop, no manure
Plot 50—Corn followed by legume cover crop, 50 pounds of manure
Plot 51—Corn followed by legume cover crop, 100 pounds of manure
Plot 52—Corn followed by legume cover crop, 200 pounds of manure

Non-Legume Section

Plot 53—Corn followed by non-legume cover crop, no manure
Plot 54—Corn followed by non-legume cover crop, 50 pounds of manure
Plot 55—Corn followed by non-legume cover crop, 100 pounds of manure
Plot 56—Corn followed by non-legume cover crop, 200 pounds of manure

The manure is spread evenly over the land before it is plowed in the spring. The quantity of manure is purposely small in order that the fertilizing effects may be kept to the minimum.

Crop of 1919

About the last of July, 1918, a mixture of vetch, alfalfa, and red and alsike clover was seeded in plots 49-52, and about the middle of October, after the corn had been cut, rye was seeded in plots 53-56. (The blowing over of the corn by storms prevented earlier seeding on these plots.)

On May 3, 1919, it was noted that there was a fair covering of vetch and clovers on plots 49-52, and a thin stand of rye, about 18 inches high, on plots 53-56.

Manure was applied to the plots in accordance with the plan and they were plowed and prepared for planting. Corn was planted on May 15. A good stand was secured and the crop was given the usual care in the way of cultivation. In August the cover crops were seeded —for the legume section a mixture of vetch and red and white sweet clover; and rye for the non-legume section.

On September 19 the corn was harvested and shocked and after the usual drying in the shock it was husked and samples prepared and dried. The analytical results are shown in table 12.

TABLE 12

Continuous Corn with Legume and Non-Legume Green Manure Crop—1919
(Calculated to the acre basis)

Plot Number	SPECIAL TREATMENT (per plot)	GRAIN			STALKS			COBS			Total Nitrogen Pounds	INCREASE OVER CHECK PLOT		
		Dry Grain Bushels	Per Cent Nitrogen	Nitrogen Pounds	Dry Stalks Pounds	Per Cent Nitrogen	Nitrogen Pounds	Dry Cobs Pounds	Per Cent Nitrogen	Nitrogen Pounds		Grain Bushels	Stalks and Cobs Pounds	Nitrogen Pounds
	LEGUME SECTION													
49	No manure	30.4	1.479	25.14	2524	.879	22.19	380	.373	1.42	48.75	......	......	......
50	50 pounds of cow manure...	37.5	1.460	30.66	2952	.867	25.59	460	.365	1.68	57.93	7.1	508	9.18
51	100 pounds of cow manure...	33.7	1.536	29.00	3088	.828	25.57	420	.307	1.29	55.86	3.3	604	7.11
52	200 pounds of cow manure...	33.2	1.517	28.23	2668	.879	23.45	432	.326	1.41	53.09	2.8	196	4.34
	Average	33.7	1.498	28.26	2808	.863	24.20	423	.343	1.45	53.91	4.4	436	6.88
	NON-LEGUME SECTION													
53	No manure	22.1	1.133	14.05	2540	.604	15.34	220	.353	0.78	30.17	......	......	......
54	50 pounds of cow manure...	16.1	1.191	10.72	2752	.564	15.52	168	.326	0.55	26.79	......	160	......
55	100 pounds of cow manure...	21.1	1.268	14.96	3036	.671	20.37	208	.334	0.69	36.02	......	484	5.85
56	200 pounds of cow manure...	24.3	1.248	16.97	2580	.604	15.58	220	.315	0.69	33.24	2.2	40	3.07
	Average	20.9	1.210	14.18	2727	.611	16.70	204	.332	0.68	32.05	0.7	228	2.97

The Influence of the Legume

Without exception the yields of grain are larger on the legume than on the non-legume section.

The highest yield on the former is 37.5 bushels per acre, and on the latter 24 bushels per acre. The average yield for the legume section is 33.7 bushels and for the non-legume section 20.9 bushels, thus showing an advantage of 12.8 bushels for the former. The yield of dry stalks is very nearly the same on the two sections.

The percentage of nitrogen is higher in both grain and stalks from the legume than from the non-legume section. It follows, therefore, that the total nitrogen recovered on the legume section is distinctly more than the amount recovered on the non-legume section.

This is shown by an average increase over the check of 6.88 pounds for the legume section and 2.97 pounds for the non-legume section. It is thus shown that of the two green-manure crops, the legume is best from the standpoint of yield and also of the quality of the feeding material produced.

The Influence of the Manure

For the legume section the manured plots show a higher yield of grain and stalks than the check plot. The greatest increase in grain is 398 pounds, or 7.1 bushels per acre, on plot 50. The same plot gives an increase in stalks equivalent to nearly ¼ ton. The increase, however, is not always proportional to the amount of manure used. Two of the manured plots in the non-legume section show smaller yields than the check plot, and the other manured plot shows only a small increase over the check. Again the legume demonstrates its superiority over the non-legume.

Summary

In the continuous growing of corn with a legume and non-legume green-manure crop and small applications of manure on each, for the introduction of decay organisms, the legume section gave a larger yield of grain with a higher percentage of nitrogen than the non-legume section.

The average yield of dry shelled corn on the legume section was about 13 bushels more than the average yield on the non-legume section.

The average percentage of nitrogen in the grain from the two sections was 1.49 for the legume and 1.21 for the non-legume.

The total nitrogen recovered through the crop from the legume section was 54 pounds per acre and from the non-legume section 32 pounds.

With reference to the manure treatment the treated plots of the legume section gave an average increase over the check plot of 4.4 bushels of grain, whereas the corresponding increase for the non-legume section was only 0.7 bushels.

THE CONTINUOUS GROWING OF WHEAT AND RYE WITH AND WITHOUT A LEGUME AS A GREEN MANURE, 1919

This constitutes the twelfth report of the work that is being carried out on this series of plots. With the exception of a crop of corn in 1908 two plots have been in wheat and two in rye every year since that time.

The plan provides for seeding one wheat plot and one rye plot to a leguminous green-manure crop immediately after harvesting the grain crop, while two other plots remain in stubble until time to prepare the land for seeding the grain again in the fall.

Thus two of the plots have added to them such nitrogen as the leguminous green-manure crop can accumulate in about 60 days while the other two go without any applied nitrogen. It may be explained here that during recent years there has been a tendency for volunteer clover to come into these two plots that remain in stubble during the summer. This, to some extent, complicates the results, but there seems no way out of the difficulty unless it is to plow the land immediately after harvesting the grain, and this practice could hardly be followed in general farm work, for the reason that just at this season there would not be time for breaking wheat stubble.

All plots receive liberal applications of acid phosphate and muriate of potash and are limed every 5 years. It is this lime and mineral treatment that encourages the growth of clover on the non-legume plots.

Crop of 1919

Immediately after harvesting the grain in 1918 plots 70 and 71 were disked and seeded to Ito San soybeans. A good stand was secured and growth was normal, showing excellent inoculation. Later, much crab-grass came in among the beans. At the time of plowing on September 23 they were 16 to 22 inches high. The ground was further prepared and acid phosphate applied at the rate of 400 pounds per acre. On account of the scarcity of potash none was applied this year. Ground oyster-shells were applied at the rate of 2 tons per acre.

On October 4 the plots were seeded to wheat and rye in accordance with the plan, namely, plots 68 and 70 to rye and 69 and 71 to wheat. The wheat and rye came through the winter in good condition and continued to grow nicely through the season. In the early part of May, trespassers did slight damage to the wheat on plot 71.

The grain was harvested July 3 and the legume plots again seeded to soybeans. The grain was weighed in the field and samples taken and prepared for analysis. The field weights of grain and straw at harvest time were as follows:

Plot No.		Pounds per acre
Rye	68—No legume	3440
	70—leguminous green-manure	4800
Wheat	69—No legume	2920
	71—leguminous green-manure	4620

The dry weights of grain* and straw, the percentage of nitrogen in the dry matter, and the total nitrogen recovered are shown in table 13.

---

* The grain of the samples which were saved from plots 68 and 70 was badly damaged by mice so that the weights of these samples could not be used in calculating the yield per acre. The yield per acre for these plots was calculated from the actual field weights of grain and straw, the average proportion of grain to straw for the six years, 1913 to 1918 inclusive, being used as a basis.

TABLE 13

Rye and Wheat with and without Leguminous Green-Manure Crop, 1919
(Calculated to the Acre Basis)

Plot No.		Dry Grain	Nitrogen		Dry Straw	Nitrogen		Total Nitrogen
		lbs.	per cent	lbs.	lbs.	per cent	lbs.	lbs.
Rye	68	1234	1.760	21.72	2560	.576	14.74	36.46
	70	1544	1.740	26.87	3280	.365	11.97	38.84
Wheat	69	800	2.055	16.44	1500	.468	7.02	23.46
	71	1000	1.986	19.86	2660	.519	13.81	33.67

From the figures given in the table it will be noted that the yields on the legume-treated plots are distinctly higher than on the non-legume plots for both wheat and rye.

The former shows an increase of 200 pounds, or over 3 bushels per acre, and the latter an increase of 310 pounds, or over 5 bushels per acre. There is also a substantial increase of straw in both cases.

Mention has already been made of the appearance of volunteer clover in the non-legume plots, especially plot 68. After the rye was harvested from the plot in 1919 notes were made to the effect that there was a fair stand of this volunteer clover—white, alsike and red. Since nitrogen is the limiting factor on this plot, the coming in of the clover tends to bring the yields nearer to the yields on the corresponding legume plot, and to this extent interferes with the carrying out of the experiment in accordance with the original plan. However, the circumstance furnishes good evidence that clover can be grown with little trouble when the conditions are made favorable. There is little difference between the nitrogen content of the dry grain from the legume plot and that from the non-legume plot, but the legume wheat plot yielded about 10 pounds more per acre of total nitrogen than the non-legume plot.

PLATE I

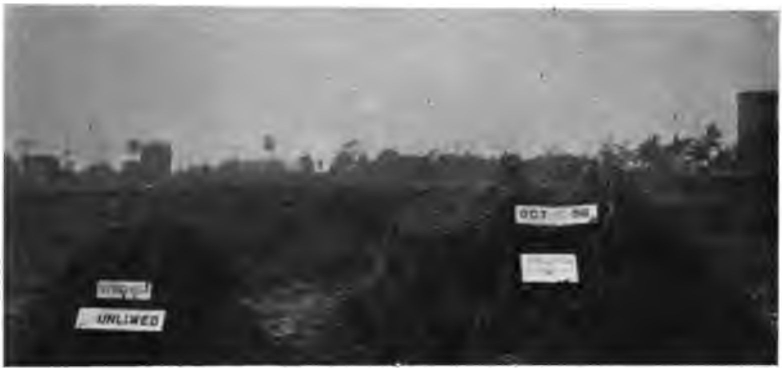

FIG. 1. VIRGINIA SOYBEANS GROWN ON UNLIMED AND LIMED PLOTS, 1918

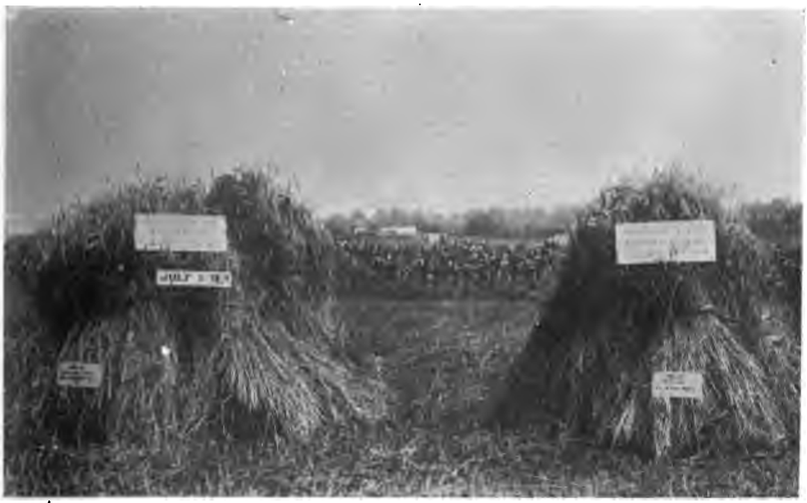

FIG. 2. RYE HARVESTED FROM CONTINUOUS RYE PLOTS, WITH AND WITHOUT A LEGUMINOUS COVER CROP, 1919

PLATE II

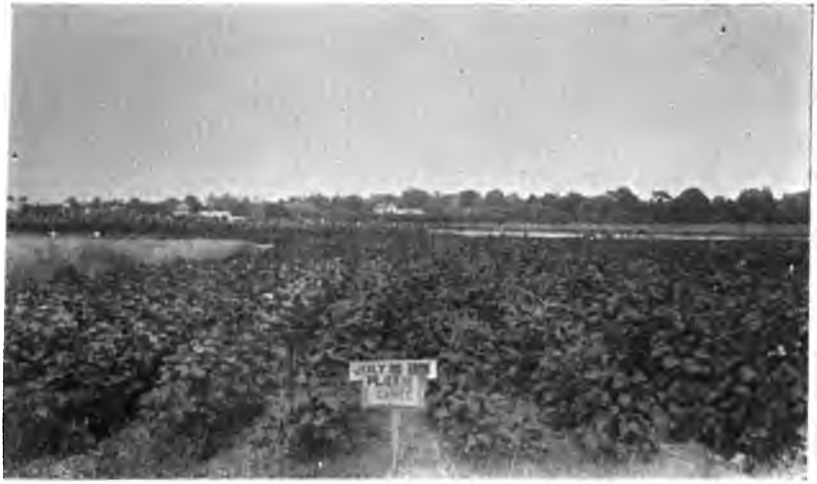

FIG. 1. BAIRD, SWAN AND WILSON SOYBEANS GROWN ON UNLIMED PLOTS, 1919

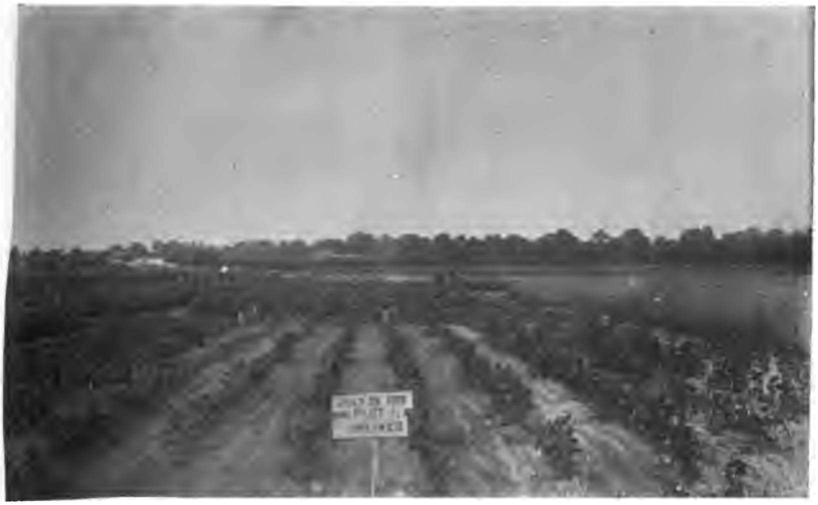

FIG. 2. BAIRD, SWAN AND WILSON SOYBEANS GROWN ON LIMED PLOTS, 1919

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REPORT

OF THE

Department of Soil Chemistry and Bacteriology

OF THE

New Jersey Agricultural (College) Experiment Station

New Brunswick, N. J.

BY

JACOB G. LIPMAN, Ph.D.
AUGUSTINE W. BLAIR, A.M.

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Report of the Department of Soil Chemistry and Bacteriology

JACOB G. LIPMAN
AUGUSTINE W. BLAIR

THE INFLUENCE OF VARYING RATIOS OF PHOSPHORIC ACID AND POTASH ON THE YIELD, AND ON THE NITROGEN AND PHOSPHORIC ACID CONTENT OF THE CROP, WITH DIFFERENT NITROGENOUS MATERIALS

A large amount of work has been done on the relative availability of nitrogenous materials in field and cylinder experiments in the presence of a constant supply of phosphoric acid and potash, but thus far little has been done along this line under conditions of a varying supply of these minerals.

In planning further work on nitrogenous fertilizers it seemed worth while to take into consideration this phase of the question, and also to further study the effect of supplying the nitrogen from more than one source.

The completion, in 1920, of the cylinder work on nitrogen availability with a soil varying in mechanical composition, made it possible to utilize the sixty cylinders which were thus released. These cylinders are of the type which has been in use at this station for the past twenty-five years.

In planning the experiment, provision was made for a constant supply of nitrogen with the phosphoric acid and potash ratios varying as follows:

N	P_2O_5	K_2O		N	P_2O_5	K_2O
5	5	4		5	5	8
5	10	4	and	5	10	8
5	15	4		5	15	8

For each of the above combinations five treatments, with reference to the supply of nitrogen, were provided, as follows:

A. No nitrogen
B. Nitrate of soda (10 gm. of the c.p. salt per cylinder)
C. Ammonium sulfate equivalent to the nitrate of soda
D. Dried blood equivalent to the nitrate of soda
E. One-third of the nitrogen from each material, equivalent to the nitrate of soda

Thus there are six different phosphoric acid-potash ratios with five treatments each, making a total of thirty treatments, and since the work is in duplicate, there are sixty cylinders in the group.

The soil is a silt loam belonging to the Sassafras series. It was taken from land which had not been farmed for many years and was quite acid, having a hydrogen-ion concentration exponent of pH 5.3. To overcome this acidity, finely ground limestone was applied to all cylinders at the rate of something over 4,000 pounds per acre.

A partial analysis of the soil gave the following results:

	Per cent
Nitrogen	.124
Phosphoric acid (P_2O_5)	.097
Potash (K_2O)	1.782
Total carbon (C)	1.563
Sulfur tri-oxide (SO_3)	.053

In addition to the nitrogen treatment, mineral fertilizers—sixteen per cent acid phosphate (10, 20 and 30 gm. per cylinder) and c. p. potassium chloride (2.1 and 4.2 gm. per cylinder)—were applied. The acid phosphate and muriate of potash were applied and mixed with the soil and the cylinders seeded to wheat October 13, 1921. Germination was good, but much of the wheat was winter-killed, and on account of the uneven stand, it was all spaded under in the spring and the cylinders re-seeded, this time to beardless barley, the seed being planted on April 13, 1922. The nitrogenous fertilizers had been reserved for a spring top dressing, and were therefore applied after the barley was planted.

Germination was good and the crop made good growth during the season. At maturity the barley was harvested and dried, the grain and straw separated and weighed, and samples of each prepared for analysis. The yields are reported in table 1. The figures given represent the averages of the duplicate treatments. A careful study of the table brings out certain interesting points, which may be summarized as follows:

(a) A distinct increase in the yield of dry matter for the nitrogen-treated cylinders over the no-nitrogen cylinders, the average weight of grain being approximately twice as much for the treated as for the untreated cylinders.

(b) A distinct increase in the yield for the cylinders having the 5-10-4 and 5-10-8 ratios over those having the 5-5-4 and 5-5-8 ratios. The series having the 5-15-4 and 5-15-8 ratio show little increase over those having the medium amount of phosphoric acid. In nearly all cases the higher potash ratio shows some increase in yield over the lower ratio. This is clearly indicated by the general averages.

(c) With one exception only, the nitrate of soda gave higher yields than either of the other nitrogenous materials, and likewise with one exception, higher than a combination of the three materials. This also is indicated by the general averages.

TABLE 1

Yield of Barley—1922

(N, P_2O_5, and K_2O used in ratios as indicated)

Series	Nitrogen Treatment	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
		gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
		Ratio 5-5-4		Ratio 5-10-4		Ratio 5-15-4		Average	
A	No nitrogen	26.6	42.2	25.0	43.8	28.3	49.7	26.6	45.2
B	$NaNO_3$	48.2	82.1	66.7	91.3	71.6	94.7	62.2	89.4
C	Ammonium sulfate	43.6	68.7	57.5	71.2	55.9	83.9	52.3	74.6
D	Dried blood	45.9	65.3	58.5	74.8	58.8	73.9	54.4	71.3
E	$\frac{1}{3}$ N from each	50.7	73.9	61.9	79.9	60.8	86.8	57.8	80.2
	Average	47.1	72.5	61.2	79.3	61.8	84.8	56.7	78.9
		Ratio 5-5-8		Ratio 5-10-8		Ratio 5-15-8		Average	
F	No nitrogen	34.8	48.3	37.5	49.0	39.4	53.6	37.2	50.3
G	$NaNO_3$	61.3	87.4	72.5	99.4	76.0	100.5	69.9	95.8
H	Ammonium sulfate	49.9	80.1	62.9	83.0	65.6	81.4	59.5	81.5
I	Dried blood	61.9	71.9	60.5	79.0	61.7	74.2	61.4	75.0
J	$\frac{1}{3}$ N from each	53.9	83.7	63.4	91.1	66.5	93.9	61.3	89.6
	Average	56.8	80.8	64.8	88.1	67.5	87.5	63.0	85.5

TABLE 2

Per Cent Nitrogen and Phosphoric Acid in Barley Grown with Nitrogen from Different Materials, and with Varying Ratios of Phosphoric Acid and Potash, Season 1922

(N, P_2O_5, and K_2O used in ratios as indicated)

Series	Nitrogen Treatment	Nitrogen		Phosphoric Acid		Nitrogen		Phosphoric Acid		Nitrogen		Phosphoric Acid	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
		per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
		Ratio 5-5-4				Ratio 5-10-4				Ratio 5-15-4			
A	No nitrogen	2.32	0.56	1.240	.271	2.30	0.64	1.244	.313	2.27	0.64	1.245	.271
B	Nitrate of soda	2.53	0.72	1.117	.202	2.27	0.55	.989	.167	2.30	0.63	1.028	.197
C	Ammonium sulfate ..	2.27	0.74	1.144	.229	2.01	0.53	1.048	.176	2.18	0.63	1.158	.250
D	Dried blood	2.35	0.60	1.120	.234	2.25	0.49	1.100	.187	2.28	0.55	1.171	.266
E	⅓ N from each of B, C and D	2.24	0.62	1.024	.182	2.14	0.56	1.053	.171	2.16	0.49	1.073	.145
	Average for N treatment	2.35	0.67	1.101	.212	2.17	0.53	1.048	.175	2.23	0.58	1.108	.214
		Ratio 5-5-8				Ratio 5-10-8				Ratio 5-15-8			
F	No nitrogen	2.15	0.50	1.174	.197	2.10	0.50	1.174	.196	2.09	0.49	1.189	.186
G	Nitrate of soda	2.44	0.59	1.006	.157	2.30	0.56	.997	.194	2.34	0.57	1.043	.199
H	Ammonium sulfate ..	2.25	0.60	1.147	.225	2.05	0.53	1.065	.197	2.15	0.60	1.107	.179
I	Dried blood	2.38	0.54	1.016	.171	2.19	0.53	1.080	.186	2.25	0.61	1.112	.231
J	⅓ N from each of G, H and I	2.24	0.51	1.100	.114	2.13	0.51	1.082	.157	2.15	0.52	1.041	.171
	Average for N treatment	2.33	0.56	1.067	.167	2.17	0.54	1.056	.183	2.22	0.58	1.076	.195

TABLE 3

Total Dry Matter and Nitrogen Recovered in Sorghum with Varying Ratios of P_2O_5 and K_2O and with Different Nitrogenous Materials (Second Crop, 1922)

(N, P_2O_5, and K_2O used in ratios as indicated)

Series	Nitrogen Treatment	Dry Matter	Nitrogen	Dry Matter	Nitrogen	Dry Matter	Nitrogen	Dry Matter	Nitrogen
		gm.	gm.	gm.	gm.	gm.	gm.	gm.	gm.
		Ratio 5-5-4		Ratio 5-10-4		Ratio 5-15-4		Average	
A	No nitrogen	86.4	.634	81.0	.618	81.9	.643	83.1	.632
B	$NaNO_3$	96.1	.690	93.8	.663	93.0	.705	94.3	.686
C	Ammonium sulfate	87.2	.681	93.6	.678	92.0	.690	90.9	.683
D	Dried blood	89.9	.630	112.8	.890	103.5	.769	102.1	.763
E	$\frac{1}{3}$ N from each	103.3	.755	98.6	.734	106.5	.739	102.8	.743
	Average	94.1	.689	99.6	.741	98.8	.726	97.5	.719
		Ratio 5-5-8		Ratio 5-10-8		Ratio 5-15-8		Average	
F	No nitrogen	85.2	.623	92.1	.633	91.2	.688	89.5	.648
G	$NaNO_3$	100.9	.747	98.6	.717	94.1	.675	97.9	.713
H	Ammonium sulfate	92.0	.633	93.5	.731	88.8	.640	91.4	.668
I	Dried blood	96.9	.733	87.9	.633	98.6	.731	94.5	.699
J	$\frac{1}{3}$ N from each	90.2	.649	95.2	.687	119.9	.779	101.8	.705
	Average	95.0	.691	93.8	.692	100.4	.706	96.4	.696

The Influence of the Phosphoric Acid and Potash Ratio on the Percentage of Nitrogen and Phosphoric Acid in the Crop

Table 2 gives the percentage of nitrogen and phosphoric acid in the grain and straw for the various treatments. A close examination of the figures indicates that a change in the phosphoric acid—potash ratio does not materially influence the nitrogen and phosphoric acid content of the grain and straw. An increase of phosphoric acid in the fertilizer does not appear to have increased or decreased the percentage of nitrogen or phosphoric acid in the crop. This is true also of the potash ratios.

Likewise there appears to be no correlation between the percentage of nitrogen and phosphoric acid in the crop and the form of nitrogenous material used.

Residual Crop of Sorghum

Following the barley, sorghum was seeded to the cylinders without further addition of fertilizers. A good crop was secured and this was harvested, weighed and prepared for analysis. The dry weights together with the total nitrogen returned in the crop are shown in table 3. With slight exception the nitrogen-treated cylinders gave larger yields than the check cylinders. This is clearly shown by comparing the average yields with the yields for series A and F (no nitrogen). This means that there was some residual effect from the nitrogenous fertilizers.

In the case of this crop it would seem that the yields have scarcely been affected at all by the different phosphoric acid—potash ratios. There is, however, a slight tendency towards higher yields with the higher amounts of phosphoric acid. The form of nitrogen used has not materially affected the yields, though the ammonium sulfate gave lower average yields than the nitrate of soda, dried blood or a combination of the three. The highest yields for this crop were obtained with the dried blood, and with the three nitrogenous materials in combination.

Percentage of Nitrogen and Phosphoric Acid in the Sorghum

The percentage of nitrogen and phosphoric acid in the dry matter are given in table 4. As in the case of the barley, changing the phosphoric acid-potash ratio has not materially influenced the percentage of nitrogen and phosphoric acid in the crop. These percentages, it will be observed, run quite constant. This is shown by the general averages and also by the averages for the nitrogen treatments.

TABLE 4

Per Cent Nitrogen and Phosphoric Acid in Sorghum Grown with Nitrogen from Different Materials, and with Varying Ratios of Phosphoric Acid and Potash—Season, 1922

(N, P_2O_5, and K_2O used in ratios as indicated)

Series	Nitrogen Treatment	Nitrogen	Phosphoric Acid	Nitrogen	Phosphoric Acid	Nitrogen	Phosphoric Acid	Nitrogen	Phosphoric Acid
		per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
		Ratio 5-5-4		Ratio 5-10-4		Ratio 5-15-4		Average	
A	No nitrogen	.734	.455	.763	.495	.785	.520	.761	.490
B	Nitrate of soda	.718	.439	.707	.458	.758	.472	.728	.456
C	Ammonium sulfate	.782	.457	.725	.474	.751	.511	.753	.481
D	Dried blood	.706	.448	.789	.458	.743	.480	.746	.462
E	⅓ N from each of B, C and D	.732	.424	.746	.439	.696	.452	.725	.438
	Average for N treatment	.735	.442	.742	.457	.737	.479	.738	.459
		Ratio 5-5-8		Ratio 5-10-8		Ratio 5-15-8		Average	
F	No nitrogen	.732	.434	.688	.441	.753	.468	.724	.448
G	Nitrate of soda	.739	.427	.727	.466	.717	.442	.728	.445
H	Ammonium sulfate	.689	.410	.782	.454	.722	.459	.731	.441
I	Dried blood	.760	.432	.720	.463	.742	.439	.741	.445
J	⅓ N from each of G, H and I	.720	.432	.720	.458	.652	.441	.697	.444
	Average for N treatment	.727	.425	.737	.460	.708	.445	.724	.444

Percentage of Nitrogen Recovered—Both Crops

Of the nitrogen that is applied, a part is recovered in the crop, a part is lost, and a small residue may be left in the soil. Nitrogen availability experiments covering a period of ten years (1) indicate that in the case of such materials as nitrate of soda and dried blood, the first crop to be planted gets a large share of the nitrogen which is not lost. These experiments have further shown that a certain amount of loss is inevitable.

In calculating the amount of nitrogen that is recovered it has been customary to assume that the amount recovered from the check plot or cylinder (that is those that received no nitrogen) represents the amount which the crop was able to get from the soil without the application of any fertilizer. Then the difference between this and the total amount recovered from the nitrogen-treated plot or cylinder would represent that part of the applied nitrogen which the crop was able to utilize.

Table 5

Percentage of Nitrogen Recovered—Two Crops, Barley and Buckwheat, 1922

(N, P_2O_5, and K_2O used in ratios as indicated)

Series	Nitrogen Treatment	Ratio 5-5-4	Ratio 5-10-4	Ratio 5-15-4	Average
		per cent	per cent	per cent	per cent
B	Nitrate of soda	61.2	73.4	82.3	72.3
C	Ammonium sulfate	42.3	45.3	51.1	46.2
D	Dried blood	37.5	67.2	55.6	53.4
E	1/3 N from each	52.2	62.8	52.9	56.0
	Average	48.3	62.2	60.5	57.0

Series	Nitrogen Treatment	Ratio 5-5-8	Ratio 5-10-8	Ratio 5-15-8	Average
		per cent	per cent	per cent	per cent
G	Nitrate of soda	69.0	76.7	76.1	73.9
H	Ammonium sulfate	37.4	48.1	46.0	43.8
I	Dried blood	59.3	42.9	48.1	50.1
J	1/3 N from each	40.4	50.5	55.6	48.8
	Average	51.5	54.5	56.5	54.2

With this figure determined, and knowing the amount of nitrogen applied, it is a simple calculation to get the percentage of nitrogen recovered.

In this work the nitrogen recovered in both crops—barley and sorghum—was used in calculating the percentage recovered. As already explained, the no nitrogen cylinders—series A and F—serve as a check against the corresponding cylinders that received nitrogen treatment. For example, the nitrogen yields of series A (both crops) for the three ratios, 0-5-4, 0-10-4 and 0-15-4, were used as a check for the corresponding treatments of series B, C, D and E, and the yields from series F as a check for the corresponding treatments of series G, H, I and J.

The percentages of nitrogen recovered under the various treatments for the two crops are shown in table 5. By referring to the averages for the different nitrogen treatments, see right-hand column, it will be noted that nitrate of soda gave the highest recovery for both the single and double potash applications, the average being a little over 73 per cent. This is a higher average than has usually been obtained with this material.

The lowest recovery was with ammonium sulfate, the average for the two sections being 45 per cent. The recoveries with dried blood and with the combination of the three materials came fairly close together.

For the 5-10-4 and 5-10-8 ratios the average recoveries are higher than with the 5-5-4 and 5-5-8 ratios. Increasing the proportion of phosphoric acid to a ratio of 5-15-4 and 5-15-8 did not materially change the recoveries.

Summary

A silt loam soil of rather high acidity—pH 5.3—was used in a study of the influence of the phosphoric acid-potash ratio on the availability of nitrogen in nitrate of soda, dried blood, ammonium sulfate and a nitrogenous fertilizer made by combining the three materials.

Finely ground limestone was applied at the rate of something over 4,000 pounds per acre. This treatment changed the reaction so that the pH value varied between approximately six and seven.

The work was carried out in duplicate, in sixty cylinders of the type that has been in use at this station for a number of years.

With constant amounts of nitrogen and potash having ratios of 1.0 to 0.8 and 1.0 to 1.6, phosphoric acid was used in amounts to give ratios of:

1.0-1.0-0.8		1.0-1.0-1.6
1.0-2.0-0.8	and	1.0-2.0-1.6
1.0-3.0-0.8		1.0-3.0-1.6

Two crops were grown, barley as a main crop and sorghum as residual crop. All fertilizers were applied for the main crop.

For the barley the nitrogen-treated cylinders showed a distinct increase in yield of grain and straw over the check cylinders.

Nitrate of soda gave the highest yields and highest percentage of nitrogen recovery, and the ammonium sulfate the lowest.

In most cases increasing the amount of phosphoric acid from one to two gave increased yields of grain and straw. A further increase of the phosphoric acid to three did not materially increase the yields.

Varying the amount of phosphoric acid and potash had practically no effect on the percentage of nitrogen and phosphoric acid in the grain and straw.

For the residual crop the nitrogen-treated cylinders, with slight exception, showed some increase in yield over the check cylinders.

Increasing the amount of phosphoric acid did not consistently increase the yields in this case. Neither were they increased materially by an increase in the amount of potash.

For this crop a change in the ratio of phosphoric acid and potash did not materially change the percentage of nitrogen and phosphoric acid in the crop.

Reference

(1) Lipman, J. G., and Blair, A. W. 1920. The Influence of the Mechanical Composition of the Soil on the Availability of Nitrate of Soda and Dried Blood—1920. *In* N. J. Agr. Exp. Sta. 42d Ann. Rept., pp. 303-316.

THE CONTINUOUS GROWING OF WHEAT AND RYE, 1922

Wheat and rye have been grown continuously on four 1/20-acre plots from 1909 to 1922, inclusive.

The object of the experiment is to determine to what extent the nitrogen supply of the soil can be maintained by growing a legume green manure crop between wheat harvest and wheat seeding, and without the use of a commercial nitrogenous fertilizer.

One plot each of wheat and rye is grown without the addition of nitrogen in any form, and one plot each is grown without commercial nitrogen, but is followed by a legume green manure crop (soybeans or cowpeas), to be plowed under for the succeeding wheat and rye in the fall. All plots receive, each year, liberal applications of acid phosphate and potash, and lime is applied once in five years.

The green manure crop usually has a growing period of about sixty days—from about the middle of July to near the middle of September. Under favorable conditions soybeans grow to a height of about two feet with pods fairly well set.

In recent years volunteer clover has been coming into the check plots (no legumes) to an extent that causes the yields on these plots to be larger than they otherwise would be. Thus the differences between the yields on the check plots and the yields on those that are seeded to soybeans are not as great as they would be could the clover be kept out. This matter could be controlled, to a large extent, by plowing the plots immediately after harvesting the wheat and the rye, and keeping the surface cultivated up to the time of seeding, about the first of October.

Following the cutting of the grain in 1921 the plots were disced, and on July 5th soybeans were drilled in on the two legume plots. Germination was fair and the beans made a good growth, so that at the time of plowing under, on September 24th, they were twenty to twenty-four inches high and showed good inoculation. At the same time there was considerable volunteer clover on the two check plots.

The land was put into good condition by discing and harrowing, and on October 3d the wheat and rye were seeded at the rate of seven pecks per acre. A good stand was obtained and growth through the season was normal. The grain was harvested about the last of June and samples saved for analysis.

Table 6 gives a record of the yields and the nitrogen returned in the crop.

The legume plots show an increase of about four bushels of grain per acre over the check plots, even though the latter were influenced by the volunteer clover. Both grain and straw from the legume plots show a higher percentage of nitrogen than from the check plots. This may possibly be attributed to a larger supply of readily available nitrogen in the legume-treated soil. The legume rye plot shows an increase in total nitrogen of nearly eighteen pounds per acre and the legume wheat plot an increase of about thirteen pounds per acre, or an average of about 15.4 pounds per acre, which would be equivalent to approximately 100 pounds of nitrate of soda.

Analysis of the Soil from the Wheat and Rye Plots

In the fall of 1922 samples of soil were collected from the wheat and rye plots and also from plot 72, which is adjacent to wheat plot 71. Plot 72 has not been cropped since 1908 and probably for a much longer period. It has, however, been kept free from vegetation and has not been fertilized.

These soils have been analyzed for nitrogen and lime requirement with the following results:

PLOT	Top-soil	Sub-soil	Lime requirement (CaO per 2,000,000 lbs. of soil)	Reaction
	per cent	per cent	lbs.	pH
68	.094	.066	200	6.8
69	.084	.059	200	6.9
70	.090	.059	200	6.9
71	.092	.061	200	6.9
72	.063	.035	600	6.3

Since analysis shows that the soil represented by these plots contained, in 1908, about .10 to .11 per cent nitrogen, it is at once evident that the nitrogen supply has not been maintained under any of the treatments. It is significant that the check rye plot number 68, which has been without nitrogen treatment for fifteen years, now contains slightly more nitrogen than the wheat and rye plots (70 and 71) on which a legume green manure crop has been grown every year. In this connection it will be recalled that note has been made of the appearance of volunteer clover on plot 68 for several years past.

Of especial interest is the low percentage of nitrogen in the soil of plot 72, from which no crops have been removed. During the fifteen year, this soil has apparently lost something like 700 to 900 pounds of nitrogen on the plowed acre basis, or an average of about fifty pounds per acre annually.

Comparing this plot with plot 68, where, as already explained, volunteer clover has been coming up for several years, it would appear that symbiotic nitrogen fixation plays a much larger part in maintaining the nitrogen supply of the soil than fixation through the free living organisms of the soil. The subsoil of plot 72 has also suffered a heavy loss of nitrogen.

TABLE 6

Rye and Wheat Grown with and without a Legume Green Manure Crop Season, 1922 (Calculated to Acre Basis)

Plot No.	Crop	Grain			Straw			Total Nitrogen
		Dry Matter	Nitrogen		Dry Matter	Nitrogen		
		lbs.	Per cent	lbs.	lbs.	Per cent	lbs.	lbs.
68	Rye alone	943	1.70	16.0	1780	.360	6.4	22.4
70	Rye followed by soybeans	1157	2.05	23.7	2280	.729	16.6	40.3
69	Wheat alone	920	1.81	16.7	1500	.432	6.5	23.2
71	Wheat followed by soybeans	1160	2.12	24.6	2240	.513	11.5	36.1

The Continuous Growing of Corn with a Legume and Non-Legume Green Manure Crop, 1922

The purpose of the continuous corn experiment is two-fold:

(a) A comparison of a legume and non-legume green manure crop.

(b) A study of the influence of small applications of manure as a means of introducing decay organisms in the soil.

The plan of the experiment is indicated under "special treatment" in the table. The plots are 1/20 acre in size. In addition to the manure, which is applied as indicated, acid phosphate and muriate of potash are applied annually at the rate of 300 and 100 pounds per acre, respectively. Nitrogen is applied in the form of nitrate of soda and sulfate of ammonia, equivalent to 160 pounds per acre of the former.

A mixture of vetch and clovers was seeded in four of the plots—49-52—the last of July, 1921, and rye was seeded in plots 53-56. Of the legume mixture, only the sweet clover and a small amount of the vetch survived the winter. The sweet clover, especially, made excellent growth in the spring, and was about two feet high when plowed under in preparing the land for corn. The rye was thin and not very strong. Manure was applied in accordance with the plan, and white cap yellow dent corn planted May 10.

On certain of the plots, especially 49-52, the stand was not good, but there was no apparent reason for this. It was replanted, but the replants were late, and the yield on these plots was on this account somewhat reduced. The crop was harvested towards the end of September and samples collected and prepared for analysis.

Table 7 indicates the manure treatment on the plot basis, and the yield of dry matter and nitrogen on the acre basis.

The Influence of the Legume

A comparison of the averages for the two sections shows 2,440 pounds of dry-shelled grain per acre for the legume section, and 1,860 pounds for the non-legume section. Thus, there is a difference of about ten bushels of grain in favor of the legume section.

Without exception, the grain from the legume section shows a higher percentage of nitrogen than the grain from the non-legume section. With one exception the same is true of the stalks. Taking the averages the total nitrogen recovered in the crop amounts to about ten pounds per acre more on the legume section than on the non-legume section.

The Influence of the Manure

For the legume section the influence of the manure is somewhat obscured by the green manure crop, though the yield on plot 52, which received 200 pounds of manure (4,000 pounds per acre), was distinctly larger than on plot 49, which received no manure. On the non-legume section the manure had a distinct effect on the yield of grain and stalks as well as on the total nitrogen recovered in the crop.

The experiment emphasizes again the value of the legume green manure as a means of furnishing the organic matter for the crop and for soil improvement.

TABLE 7

Continuous Corn with Legume and Non-Legume Cover Crop, Season, 1922 (Calculated to Acre Basis)

Plot No.	Special Treatment	Grain			Stalks				Increase Over Check		
		Dry Matter	Nitrogen	Nitrogen	Dry Matter	Nitrogen	Nitrogen	Total Nitrogen	Grain	Stalks	Nitro-gen
		lbs.	per cent	lbs.	lbs.	per cent	lbs.	lbs.	lbs.	lbs.	lbs
	Legume Section										
49	No manure	2480	1.290	31.99	2200	.599	13.18	45.17	....	....	....
50	50 lbs. manure	2320	1.310	30.39	2400	.648	15.55	45.94	....	200	.77
51	100 lbs. manure	1920	1.305	25.06	2240	.628	14.07	39.13	....	40	....
52	200 lbs. manure	3040	1.267	38.52	2960	.518	15.33	53.85	560	760	8.68
	Average	2440	1.293	31.49	2450	.598	14.53	46.02	187	333	3.15
	Non-Legume Section										
53	No manure	1560	1.109	17.30	2320	.518	12.02	29.32	....	....	....
54	50 lbs. manure	1960	1.123	22.01	3200	.469	15.01	37.02	400	880	7.70
55	100 lbs. manure	2160	1.160	25.06	2960	.412	12.20	37.26	600	760	7.94
56	200 lbs. manure	1760	1.138	20.29	2520	.778	19.61	39.90	200	320	10.58
	Average	1860	1.132	21.17	2750	.544	14.71	35.88	400	653	8.74

THE INFLUENCE OF LIME ON THE YIELD AND NITROGEN CONTENT OF SOYBEANS, 1922.

Six varieties of soybeans were grown on limed plots, and also on corresponding unlimed plots, and six other varieties were grown on limed plots only.

Beans have been grown on these plots continuously since 1913, and the unlimed land is becoming very acid and its supply of available nitrogen is badly depleted.

The limed plots continue to produce good crops, the average this year being between twenty-one and twenty-two bushels per acre. The yields and other data for the 1922 crop are reported in table 8.

The unlimed plots gave an average yield of three bushels per acre, while the corresponding limed plots gave an average yield of 21.2 bushels per acre. The other six varieties having no corresponding unlimed plots gave an average yield of 22.1 bushels per acre.

In former years the average percentage of nitrogen in the beans from the limed plots has been higher than in the beans from the corresponding unlimed plots, but this year there is practically no difference. There is, on the other hand, a great difference in the total amount of nitrogen recovered in the crop, the average for the unlimed series being 14.8 pounds per acre and for the limed series 92.8 pounds per acre (99.5 pounds per acre for the other six varieties).

The average yield of dry stalks was about 1,850 pounds per acre for the limied plots and 334 pounds for the unlimed plots.

The average percentage of nitrogen in the stalks from the limed plots is slightly below that from the unlimed plots. This may be due to the fact that the plants from the unlimed plots were very small and stunted, thus making it difficult to hull out all of the beans.

Ten of the twelve varieties yielded twenty bushels per acre or over. Four varieties yielded 100 pounds of nitrogen per acre. The same soil returns only about twenty-five to fifty pounds of nitrogen per acre in non-legume crops such as grain, hay and corn.

It is significant that no nitrogen has been applied to these plots for a period of ten years. Moderate applications of acid phosphate and muriate of potash are made annually.

TABLE 8

The Influence of Lime on the Yield and Nitrogen Content of Soybeans—1922 (Calculated to the Acre Basis)

VARIETY	Shelled Beans						Stalks						Total Nitrogen Recovered	
	Limed			Unlimed			Limed			Unlimed				
	Dry Beans	Nitrogen		Dry Beans	Nitrogen		Dry Stalks	Nitrogen		Dry Stalks	Nitrogen		Limed	Un-Limed
	bu.	per cent	lbs.	bu.	per cent	lbs.	lbs.	per cent	lbs.	lbs.	per cent	lbs.	lbs.	lbs.
Baird	20.4	6.75	82.62	4.4	7.05	18.61	1476	.734	10.83	456	1.167	5.32	93.45	23.93
Swan	24.4	6.47	94.72	1.3	6.42	5.01	2616	.864	22.60	132	1.152	1.52	117.32	6.53
Wilson	22.4	5.88	79.03	.9	5.55	3.00	2316	.648	15.01	126	1.008	1.27	94.04	4.27
Ebony	22.1	6.50	86.19	1.8	6.51	7.03	1554	.778	12.09	372	1.434	5.33	98.28	12.36
Edna	22.0	5.88	77.61	4.8	5.59	16.10	2100	.518	10.88	612	1.066	6.52	88.49	22.62
Minn. No. 115	15.6	5.98	55.97	4.6	6.24	17.22	1074	.844	9.06	306	0.662	2.03	65.03	19.25
Average	21.2	6.24	79.36	3.0	6.23	11.16	1856	.731	13.41	334	1.082	3.67	92.77	14.83
Haberlandt	20.1	5.75	69.35				2334	1.146	26.55				95.90	
Manchu	26.7	6.47	103.65				1998	.930	18.58				122.23	
Manhattan	16.9	6.41	65.00				1338	.801	10.72				75.72	
Austin	24.1	6.17	89.22				2034	.743	14.91				104.13	
Elton	20.5	6.69	82.29				1230	.734	9.03				91.32	
Virginia	24.2	6.32	91.77				2148	.729	15.66				107.43	
Average	22.1	6.30	83.55				1847	.847	15.91				99.46	

Analysis of the Soil from the Soybean Plots

Samples of soil were collected from these plots in 1918 and again in 1922, and analyzed for total nitrogen and lime requirement. The results are shown in table 9.

TABLE 9

Percentage of Nitrogen in Limed and Unlimed Soil

PLOT	Top soil		Sub-soil 1922	Lime requirement (CaO per 2,000,000 lbs. soil)		Reaction 1922
	1918	1922		1918	1922	
	per cent	per cent	per cent	lbs.	lbs.	pH
M-limed	.103	.094	.040	600	800	6.3
Q-limed	.109	.100	.065	800	1200	6.2
N-unlimed	.085	.077	.063	1600	2200	4.8
R-unlimed	.095	.087	.048	1500	2400	4.8
O-limed	.090	....	....	600	....	....
P-limed	.104	....	....	600	....	....

This soil originally contained about 0.1 per cent nitrogen. On the limed plots this has been very nearly maintained, notwithstanding the fact that the beans and vines have been removed each year for a period of ten years.*

On the other hand, there has been a consideable loss of nitrogen from the unlimed plots. The soil of these plots has become quite acid as shown by lime requirement, and for several years, as previously noted, the beans have been almost a failure. There was therefore, little chance for symbiotic fixation of nitrogen, and at the same time constant cultivation gave opportunity for loss of nitrogen through leaching.

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*Lime in the carbonate form was applied in 1913 at the rate of 4,000 pounds per acre and again in 1918 and 1922 (after samples were taken).

NUMBERS OF MICROORGANISMS, NITRIFYING AND CARBON-DIOXIDE PRODUCING CAPACITY, AND SOIL FERTILITY

SELMAN A. WAKSMAN and ROBERT L. STARKEY

It has been pointed out elsewhere that a careful study of numbers of microörganisms in the soil and the nitrifying capacity of the latter tend to give information towards the solution of soil fertility problems. Certain tendencies are indicated which point to a correlation between the results obtained from these bacteriological studies and soil productivity, allowing, of course, for the influence of the fertilizing elements added to the soil and change in reaction brought about by liming.

A study of the carbon-dioxide producing capacity of the soil has tended to give information in the same direction. Van Suchtelen, Neller and others pointed out that carbon-dioxide production in the soil may serve as a sensitive index of soil fertility. Most of these invesigators have determined the carbon-dioxide producing capacity of the soil by adding a small amount of dextrose, alfalfa meal or other organic substance, then measuring the CO_2 given off in a certain length of time, under constant temperature and moisture conditions.

The studies carried on in our laboratory were conducted both with fresh soil alone and with soil to which a small amount of organic matter had been added. The evolution of carbon dioxide from the soil itself (in these experiments the CO_2 was measured from portions of soil sealed into an enclosed system), is affected by the amount and kind of organic matter present in the soil, as well as the physical and chemical condition of the soil influencing the rapidity of the decomposition of this organic matter. The formation of CO_2 when a small amount of undecomposed organic matter is added, indicates the rapidity with which the particular soil will decompose organic matter and oxidize it to CO_2.

The nitrifying capacity of the soil has been determined by five different methods:

1. Measuring the amount of nitrate accumulating in the soil itself, when kept for 28-30 days under optimum conditions of moisture and temperature.
2. Nitrification of ammonium sulfate.
3. Same as 2, but in the presence of a theoretical amount of $CaCO_3$ sufficient to neutralize all the acids formed.
4. Nitrification of 0.25 per cent dried blood.
5. Nitrification of ammonium sulfate in a synthetic medium (solution or sand) by a small amount of soil. These methods as well as the methods for determining numbers of microörganisms were described in detail elsewhere.

It is sufficient to give here the results obtained from three characteristic plots of the nitrogen series of plots at this station: 7A is the control plot receiving no fertilizer treatment; 7B receives only two tons of limestone per acre every five years; 5A receives annually minerals and manure and no lime. The results of the bacteriological analyses of these three plots and the crop yields (timothy) for 1922 are given here:

Plot No.	Crop yield per acre	Relative numbers of micro-örganisms	Relative nitrifying capacity	CO_2 production	
				In 1 kgm. ot soil (14 days' incubation)	In 200 gm. of soil + 0.5 gm. dextrose (24 hours' incubation)
	lbs.			mgm.	mgm.
7A	328	100	100	70.0	53.8
7B	960	151	395	107.1	139.5
5A	5600	262	430	227.4	239.0

These studies will be reported in deail elsewhere.

STUDIES IN THE SOIL SALT SYSTEM—A SPECIAL DEVICE FOR THE CONTINUOUS PERCOLATION OF SOLUTIONS THROUGH CYLINDRICAL MASSES OF SOIL

R. V. Allison

While observations upon the effect of the withdrawal of soluble salts by washing or by plant assimilation upon the physical disposition of the colloidal fraction of the soil with which they are in equilibrium have been made both under field and greehouse conditions, it was found desirable to study further the effect of such movement by washing in the laboratory, and the apparatus for this purpose, indicated in figure 1, was independently devised. An apparatus somewhat similar to the one here shown at B in figure 1, has been described recently by Nolte (1). Reference is made to that phase of the procedure which provides for a stronger pressure against the soil column through the use of a long siphon arm from a higher solution level. In these studies the degree of dispersion of the colloidal materials of a soil resulting from any particular treatment is interpreted upon the basis of the permeability of the column to water.

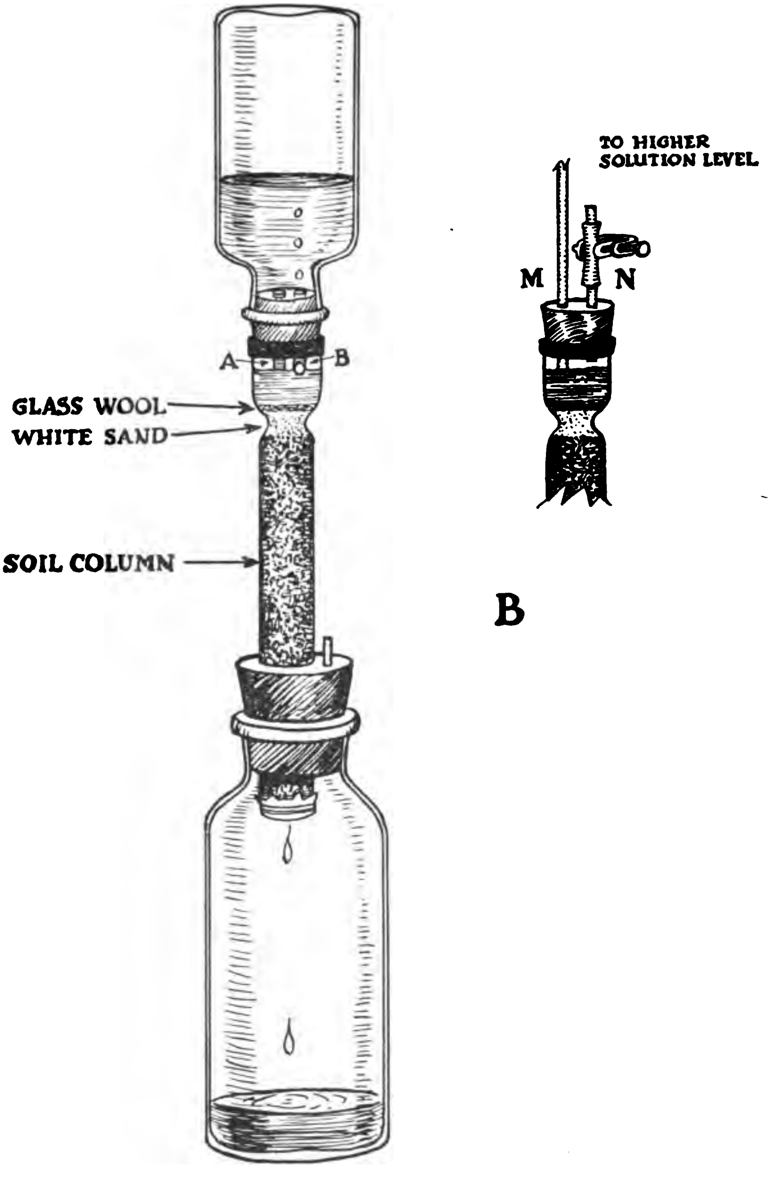

FIG. 1. Diagram of apparatus for percolation of solutions through soil.

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